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FOR REVIEW.

[See *Publications*, A. S. P., vol. VIII, p. 101.]

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The Record-Union, Sacramento, California.
The Times, Los Angeles, California.
The Tribune, Oakland, California.

A METHOD FOR DETERMINING THE VALUE OF AN AVERAGE SPACE OF A LATITUDE-LEVEL IN TERMS OF A MICROMETER-TURN.

By Frank Schlesinger.

In the determination of latitudes by means of the zenith-telescope it is necessary to know the average value of the spaces on the latitude-level. The following method has the advantage of being executed under precisely the same conditions that prevail during the observations for latitude themselves.

Two stars having nearly equal declinations and differing a few minutes in Right Ascension are selected. The telescope is pointed so that both will transit near the middle of the field, and micrometer-readings are taken upon each. Between the two transits, however, the telescope's inclination is changed so that the bubble of the latitude-level traverses several divisions. Consequently, the difference of micrometer-readings ($\Delta' R$) should be corrected by the difference of level-readings ($\Delta' l$), in order to obtain the true difference of declination ($\Delta\,\delta$) between the two stars. That is—

$$\Delta' R \pm \Delta' l = \Delta\,\delta$$

On a succeeding night the same observation is to be made upon the same stars, with this exception: the inclination of the telescope must be changed in the opposite direction between the two transits, so that if on the previous night the level-readings had been increased they must now be decreased, or *vice versa*. We now have,

$$\Delta'' R \mp \Delta'' l = \Delta\,\delta$$

As we may assume that the difference of declinations is the same as on the previous night, we get by subtraction,

$$\Delta'' R - \Delta' R = \Delta'' l - \Delta' l$$

This enables us to express one space of the level in terms of one turn of the micrometer, which is what was required. It will be noticed that accurate knowledge of the declinations is by no means necessary, and that therefore the two stars may be selected from the *Durchmusterung*. Indeed, suitable stars may usually be found by pointing the telescope quite at random in the meridian.

The following is a numerical example from actual observation. The zenith telescope employed, like all other modern ones, is provided with two latitude-levels; but for the sake of clearness data are given only for the upper one.

	Right Ascension.	Declination (1900).
Star 1	9h 14m 50s	− 40° 11′ 40″
Star 2	9 25 45	40 10 30

1900, April 8: Star 1

Level Readings. North End.	South End.	Micrometer Readings.
5.9	28.6	15.5355

1900, April 8: Star 2

13.8	36.6	13.0350

1900 April 9: Star 1

16.0	37.8	15.2435

1900, April 9: Star 2

5.4	27.4	13.2515

Hence, we have,

$$\Delta' R = 2.5005 \qquad \Delta' l = -\ 7.95 \text{ divisions}$$
$$\Delta'' R = 1.9920 \qquad \Delta'' l = -10.50$$

Consequently, one division of the level is equivalent to

$$\frac{0.5085}{18.45} = 0.0276 \text{ micrometer turns.}$$

Nine determinations similar to the above gave only $0^{\text{r}}.0004$ as the probable error of a single determination. This corresponds to $0''.016$, one turn of the micrometer being about $40''$.

The above method, appropriately modified, may also be applied to striding-levels of meridian instruments.

UKIAH, CALIFORNIA, January 22, 1901.

OBSERVATION OF *LEONIDS* AT POMONA COLLEGE, CLAREMONT, CALIFORNIA.

COMMUNICATED BY F. P. BRACKETT.

After the disappointment of last year, when an organized force of over fifty observers was trained for a campaign of at least a week, with charts and tables, and three photographic stations, and were met with almost total cloudiness all the week and a general failure of *Leonids* to attack all along the line, the astronomy class of Pomona College entered upon the observation of *Leonids* this year with more quiet and modesty. The plan of observation covered every night from November 12th to 17th, but the weather was so unfavorable that careful watch and record was kept only during the hours from 12 to 4 A.M. on the mornings of November 14th to 16th. This time was divided into periods of half an hour each, with three or more observers for each period. One noted the time of every call, a second kept the count, while the third mapped and described as many meteors as possible. Meteor paths were charted each night, but the limited knowledge of uranography and lack of experience on the part of the amateur observers rendered them unsatisfactory for the discussion of radiant points. Less than thirty were seen in *Leo* and the adjacent constellations, and over thirty in *Gemini*, *Auriga*, *Taurus*, and *Orion*, while nearly fifty were seen in the circumpolar constellations visible, chiefly in *Ursa Major*. Beside the *Leo* radiant, there seems to be one also in *Gemini* between α, β, τ, and T.

The results are exhibited chiefly in the accompanying tables.*

The whole number would, of course, have been much larger if there had been no moonlight. For the twenty periods during which they were seen, the average interval was five minutes; for the three periods from 12:30 to 2:00 Friday morning, it was $1^m\ 12^s$. Twice, a little before 2 o'clock, two were seen at once, and there were thirteen intervals of less than one minute. During all the remainder of the time there were only seven such intervals. Any attempt, however, to discuss the frequency of fall must be unsatisfactory because of the haze and cloudiness at times. More might have been seen during the later periods of the 15th and 16th if the sky had been clear, and the larger numbers in the second, third, and fourth period of the 16th may have been due to the absence of moonlight; yet the order of results is probably correct, and indicates that the greatest number fell on the 16th, and the least on the 15th. The large proportion of non-*Leonids* is noticeable.

About seventy-five, or three fifths, of the meteors observed

* Table I, giving detailed description of the individual meteors is here omitted. The initials in the column "Observer" in Table II stand respectively for students CONE, KELSO, WARNER, BAKER, BIXBY, DAY, JENCKS, G. SMITH, STEWART, VOORHEES, BALDWIN, H. SMITH, MCFADDEN, LESTER, A. GOULD, T. GOULD, MOLES, MCLEAN, and STEFFA.

TABLE II.— RESULTS OF OBSERVATION BY PERIODS.

Date.	No.	Time.	No. of Meteors.	No. of *Leonids.*	Field.	Weather.	Observer.
Nov.		Begin. End.					
14	I	12:00 – 12:30	5	3	East......	Clear	C. K. W.
14	II	12:30 – 1:00	5	2	"	"	" " "
14	III	1:00 – 1:30	3	3	"	"	" " "
14	IV	1:30 – 2:00	11	3	"	"	" " "
14	V	2:00 – 2:30	7	5	E. N. & Z.	"	Ba. Bi. D.
14	VI	2:30 – 3:00	2	2	" "	"	" " "
14	VII	3:00 – 3:30	5	5	Whole sky	"	" " "
14	VIII	3:30 – 4:00	9	6	" "	"	" " "
15	IX	12:00 – 12:30	1	0	N. & E. ..	Cloudy except near the zenith.	J. Sg. St. V.
15	X	12:30 – 1:00	0	0	" " ..		" " " "
15	XI	1:00 – 1:30	2	1	" " ..		" " " "
15	XII	1:30 – 2:00	4	1	" " ..		" " " "
15	XIII	2:00 – 2:30	3	2	....		" " " "
15	XIV, XV, XVI	2:30 – 4:00	0	0	....	Cloudy......	Bl. Sh. Mf. L.
16	XVII	12:00 – 12:30	8	1	Whole sky	Hazy E. & S.	Ga. Gt. Mo. Mc. Sf.
16	XVIII	12:30 – 1:00	15	5	"	" "	" " "
16	XIX	1:00 – 1:30	13	2	"	" "	" " "
16	XX	1:30 – 2:00	13	6	"	" "	" " "
16	XXI	2:00 – 2:30	6	1	E. N. & Z.	Hazy........	Ba. Bi. D.
16	XXII	2:30 – 3:00	3	0	" "	More hazy...	" " "
16	XXIII	3:00 – 3:30	4	2	" "	" " ...	" " "
16	XXIV	3:30 – 4:00	1	1	" "	Cloudy......	" " "
			120	49			

TABLE III.

Time.	Total Number of Meteors.			Number of *Leonids.*		
A. M.	Nov. 14th.	15th.	16th.	Nov. 14th.	15th.	16th.
12:00 – 12:30 ..	5	1	8	3	0	1
12:30 – 1:00 ..	5	0	15	2	0	5
1:00 – 1:30 ..	3	2	13	3	1	2
1:30 – 2:00 ..	11	4	13	3	1	6
2:00 – 2:30 ..	7	3	6	5	2	1
2:30 – 3:00 ..	2	0	3	2	0	0
3:00 – 3:30 ..	5	0	4	5	0	2
3:30 – 4:00 ..	9	0	1	4	0	1
Total.....	47	10	63	27	4	18

were between the second and fourth magnitudes; twenty were of first magnitude and higher; six of class — 1, and one — 2.

Three fourths were white or yellow, in about the same proportion, and about five each of blue, green, orange, and red.

The duration of half were too swift for estimation, and nearly fifty more were seen for less than one second. Only five were visible for more than one second.

Both duration and length of path were doubtless shortened by moonlight and cloudiness. A course of some 30° and over was traced for about twenty, from 15° to 20° for about thirty, some 10° for about fifty, and a shorter course of 5° or 6° and less for about twenty.

ASTRONOMICAL OBSERVATIONS IN 1900.

MADE BY TORVALD KÖHL, AT ODDER, DENMARK.

VARIABLE STARS.

*Z Cygni.**

March	23:	Z = d.	October	16:	= b.
	30:	id.		21:	id.
April	18:	= e.		23:	id.
	25:	< e.		28:	id.
August	27:	id.	November	12:	= a-
			December	22	= c.

S Ursæ majoris.†

Jannary	25:	S = d.	September	2:	id.
February	20:	< c.		13:	{ < d. / > e. }
March	1:	a little > d.		15:	= d.
	7:	id.		18:	id.
	14:	id.		25:	id.
	23:	= e.		26:	id.
	30:	id.	October	14:	{ > d. / < c. }
April	18:	{ < e. / a little > f. }		23:	= d.
	25:	< e.		28.	id.
August	16:	= e.	November	11:	a little < e.
	27:	id.	December	22:	< g.
	29:	id.			

* *Vide* the sketch in the *Publications* A. S. P., No. 48, page 69.
† *Vide* the sketch in the *Publications* A. S. P., No. 73, page 56.

T Ursæ majoris. *

January 25: T = e.
February 20: > a (= 7.0 Mag.)
March 1: id.
7: id.
14: id.
23: id.
30: = a.
April 18: { < a. / > b. }
25: a little > c.
August 16: invisible.
27: < g.
29: id.
September 2: id.
13: id.
15: id.
18: id.
25: id.
26: id.
October 14: { < e. / > f. }
23: = d.
28: = c.
November 11: > a.
December 22: a little > a.

W Pegasi. †

January 25: W invisible.
February 20: id.
August 27: = e.
September 2; a little < e.
13: < e.
18: id.
26: = f.
October 14: < g.
23: id.
November 12: extremely faint,
December 22: invisible.

The Star BD. + *46°.2970.*

When I observed the new variable BD. + 46°.2966 on October 28th, I was surprised to find that the star BD. + 46°.2970, which is very faint in the sketch by WILLIAMS (*Astron. Nachr.*, 3629) now was much brighter and = d in the sketch. On October 30th it was even > d, and it showed the same brightness on October 31st, November 10th, 11th, 12th, and December 22d. In *Astron. Nachr.*, 3673, Dr. ERNST HARTWIG has confirmed the remarkable change in brightness. The star is supposed to vary between the ninth and tenth magnitudes in a period not yet known.

SHOOTING STARS.

No.	Time.	Beginning.	End.	Mag.	Note.
	h m s	° °	° °		
1	Aug. 9, 10 16 15 P.M.	291 + 0	280 — 4	♀	Train.
2	17 20	310 + 55	274 + 37	2	
3	21 20	32 + 75	250 + 82	2	
4	55 0	330 + 76	255 + 77	2	
5	11 11 0	348 + 63	318 + 74	3	

* *Vide* the sketch in the *Publications* A. S. P., No. 22, page 63.
† *Vide* the sketch in the *Publications* A. S. P., No. 60, page 23.

6	19 50	17 + 17	11 + 14	1	
7	27 10	14 + 41	7 + 35	1	
8	29 15	6 + 26	347 + 17	♀	Yellow train.
9	30 0	11 + 58	359 + 57	3	
10	37 45	19 + 76	46 + 72	1	
11	11 40 20	355 + 46	4 + 38	2	
12	50 25	250 + 75	208 + 71	1	Red.
13	52 10	180 + 67	169 + 65	2	
14	56 50	354 + 52	5 + 44	3	
15	Aug. 11, 10 21 5	228 + 32	216 + 20	2	
16	22 40	8 + 34	17 + 37	♃	
17	27 30	2 + 21	351 + 13	2	
18	11 2 55	312 + 40	288 + 27	♀	Red.
19	14 0	28 + 50	38 + 42	3	
20	21 50	324 + 17	325 + 4	1	
21	28 0	135 + 66	156 + 57	2	
22	31 50	310 + 70	262 + 54	2	
23	37 0	252 + 28	235 + 27	2	
24	47 20	355 + 40	344 + 35	1	
25	57 40	270 + 36	261 + 18	1	
26	Aug. 20, 10 9 0	341 + 26	345 + 33	4	
27	19 10	322 + 62	280 + 39	2	
28	42 0	7 + 46	10 + 37	4	
29	43 40	298 − 7	302 − 16	2	
30	44 50	332 + 3	335 − 2	3	
31	45 0	337 + 10	332 − 1	3	
32	51 30	239 + 17	249 + 9	2	

No. 16. This meteor was also observed at Copenhagen: 184° + 63° (end point).

No. 20. Also observed at Copenhagen: 257° + 21° ⟶ 255° + 10°.

No. 22. End point observed at Copenhagen: 227° + 31°.

The three meteors named have given the following results:—

No.	Beginning.			End.			Real Length of the Path.	Observer.
	h	λ	ϕ	h	λ	ϕ	β	
		° ′	° ′		° ′	° ′		
16	...	...	...	72	0 48	56 18	..	Torvald Köhl. Otto Asmussen.
20	99	1 48	55 18	71	1 47	55 11	32	Torvald Köhl. Otto Asmussen.
22	...	...	...	114	3 15	56 6	..	Torvald Köhl. Otto Asmussen.

*** h and β are expressed in kilometers; λ is W. long. from Copenhagen; ϕ is N. lat.; h is the altitude of the meteor above the Earth's surface.

Odder is situated in 2° 25′ W. long. from Copenhagen and 55° 58′ N. lat.

FIREBALLS.

In the past year fifteen fireballs have been seen from stations in Denmark.

No.	Time.	Beginning.	End.	Mag.	Station.	Note.
1	Jan. 1, 1 h 1 m A.M.	140° + 35°	115° + 2°	♀	Odder..........	Train, lasting 5 seconds.
2	15, 5 27 P.M.	......	NNE. 45° alt.	∗	Stubbeköping...	Explosion.
3	Feb. 8, 9 30	......	NNE. 45° alt.	∗	Otterup.........	Explosion.
4	May 3, 10 20	......	NW. 70° alt.	∗	Himmelbjerg ...	Train, lasting for several seconds, illuminating the country.
5	June 14, 9 12	352° + 46°	331° + 32°	¼☾	Holbek.........	Explosion; blue; duration 2 to 3 seconds. Seen from several stations.
6	21, 10 30	Zenith.	NNW.	♀	Odder..........	Explosion.
7	Aug. 15, 8 40	......	246° — 17°	∗	Holbek.........	Train, for 4 seconds. Same meteor was seen in Sonderburg, illuminating the town, and burst into 20 to 30 pieces.
8	Sept. 14, 11 15	......	NE. 12° alt.	∗	Hellerup........	White.
9	Oct. 1, 8 59	......	ESE. 30° alt.	¼☾	Kolding........	Red.
10	20, 7 45	SW.	NE.	∗	Lemvig.........	Red-yellow train.
11	10 30	......	W.	∗	Birkeröd........	Train.
12	Nov. 5, 5 51	165° + 55°	209° + 26°	♀	Præstö	Very slow; durat'n 10 s.
13	9, 12 22 A.M.	78 — 11	82° — 16°	♀	Præstö	Train.
14	Dec. 16, 4 40 P.M.	......	S.W. 8° alt.	☾	Copenhagen....	Beautiful train, lasting a quarter to half an hour.
15	9 13	E.	S.	∗	Snekkersten....	Explosion.

Large Fireball.

Among the meteors of this year No. 14 was of special interest. About this fireball, observed by thousands of men in Denmark, Northern Germany, and Holland, I received seventy-three letters from as many observers in the countries named. In the southern part of Sjælland the opinion of a large *comet* arose, because the train of the meteor lasted so long. Two observers at Copenhagen thought the phenomenon was only at a few miles distance, but as from *all* stations in Denmark it was standing near the horizon in the southwest, where the Sun lately had been setting, it was evident that the fireball must have passed over Northwestern Germany. This opinion was soon confirmed. From Hamburg and Bremen the phenomenon was seen rather in a *westerly* direction, from Wilhelmshafen to the *south*, from Amsterdam to the southeast, and from Cöln to the *north*.

The fireball lighted up the whole country, and thousands of spectators were frightened and looked astonished at the sparkling object that, like another moon, was traveling across the sky. In fact it is told that some children in a German village rushed into the house, crying: "Papa! Mama! Come out directly! The moon fell down from the sky just now, and is sticking in Minnermann's tree!"

The meteor whirled about on the last part of its path, then suddenly it burst into pieces with a rain of sparks, flashed up in a bluish light, dashed downward, and disappeared. Afterwards a large train was seen, at first forming a straight line, then a broken one like a lightning-flash. After that the figure of an S was seen and after twelve to fifteen (from Hamburg is said thirty) minutes the faint remainders of the train finally disappeared. It is not yet certain *where* the fireball fell to the ground, if it fell at all. Perhaps it took place in the southern part of Oldenburg.

In the past year a little transit-instrument (Gustav Heyde, in Dresden) has been erected in the garden, and a wedge-photometer (Joepfer, in Potsdam) for observations of variable stars has been attached to the 3-inch Steinheil refractor. Since 1900, April 1st, the private observatory at Odder has received a yearly grant from the Danish Government.

PLANETARY PHENOMENA FOR MARCH AND APRIL, 1901.

By Malcolm McNeill.

March.

The Sun is at the vernal equinox, and spring begins, March 20th, 11 P.M., P. S. T.

Mercury is an evening star at the beginning of the month, setting just about an hour after sunset, but it rapidly nears the Sun and passes inferior conjunction on March 7th. After that it is a morning star, rapidly moving away from the Sun, and by the end of the month is well out toward greatest west elongation, and rises about an hour before sunrise.

Venus is still nearer the Sun than during February, and at the end of the month rises only a few minutes before it. The interval is considerably shortened for points in the northern hemisphere by the fact that the planet arrives at its greatest heliocentric south latitude toward the close of the month, and is apparently several degrees south of the Sun. The conditions for visibility during the month are very poor.

Mars is the only one of the planets in good position for evening observation (except *Neptune*, which requires a telescope). It is above the horizon nearly the entire night, and its brightness makes it quite conspicuous, although toward the end of the month it has begun to be perceptibly less brilliant than it was during opposition in February. It increases its distance from the Earth about twelve millions of miles during the month, and at the end is about seventy-five millions from us. It moves about 7° westward and northward during the month in the constellation *Leo*, and on March 9th it passes about 4° north of *Regulus*, the brightest star of the constellation, and about 1° south of η *Leonis*, the star at the junction of handle and blade of the Sickle.

Jupiter and *Saturn* are still morning objects, but toward the close of the month they rise before 2 A. M. They are both in the constellation *Sagittarius*, a few degrees north of the group known as the Little Dipper. Their distance apart changes from about 6° on March 1st, to about 4½° on March 31st, *Jupiter* being somewhat higher up than *Saturn*.

Uranus rises about two hours earlier than *Jupiter* and *Saturn*, and is in the southern extension of *Ophiuchus*.

April.

Mercury is a morning star throughout the month, and comes to greatest west elongation on April 3d. Its apparent distance from the Sun is then nearly 28°, which is 10° more than its distance at the greatest east elongation, in February; but as it is also nearly 12° south of the Sun, the maximum interval between the rising of the Sun and the planet is only a little more than an hour, and the conditions for visibility are rather poor.

Venus is very close to the Sun throughout the month — too near to be seen, unless under exceptional circumstances. It comes to superior conjunction on the afternoon of April 30th, and becomes an evening star, to remain so for ten months.

Mars is still in good position for evening observation, but is gradually losing its brilliancy. It increases its distance from the Earth about twenty millions of miles during the month, and on April 27th its distance from the Earth is the same as the Earth's mean distance from the Sun. It is in the constellation *Leo*, and after moving a little westward it turns and moves eastward from April 5th. At the end of the month it has moved about 3° from its westernmost position. It is also continually moving southward, so that as it comes back it travels on a line much nearer *Regulus* than during its westward motion. At the end of the month it is 1° west and 2° north of the star.

By the end of April *Jupiter* and *Saturn* rise before midnight. They are a little closer together than during March, and in the constellation *Sagittarius*. Both move slowly eastward until nearly the close of the month, *Saturn* until April 25th, and *Jupiter* five days longer. *Jupiter* is then a little more than 3° west and 0° 44′ south of *Saturn*. The third-magnitude star π *Sagittarii* lies a little north and between them. The opening of *Saturn's* rings is a trifle less than it was a year ago, but has not yet diminished much from the maximum.

Uranus rises before 10 P.M. at the close of the month. It is retrograding — moving westward, in the southern extension of *Ophiuchus*. No very bright star is near it, and it is not easy to make out.

Neptune is an evening object in the western sky on the border line between *Taurus* and *Gemini*.

Explanation of the Tables.—The phases of the Moon are given in Pacific Standard time. In the tables for Sun and planets, the second and third columns give the Right Ascension and Declination for Greenwich noon. The fifth column gives the local mean time for transit over the Greenwich meridian. To find the local mean time of transit for any other meridian, the time given in the table must be corrected by adding or subtracting the change per day, multiplied by the fraction whose numerator is the longitude from Greenwich in hours, and whose denominator is 24. This correction is seldom much more than 1^m. To find the standard time for the phenomenon, correct the local mean time by *adding* the difference between standard and local time, if the place is west of the standard meridian, and *subtracting*, if east. The same rules apply to the fourth and sixth columns, which give the local mean times of rising and setting for the meridian of Greenwich. They are roughly computed for lat. 40°, with the noon Declination and time of meridian transit, and are intended as only a rough guide. They may be in error by a minute or two for the given latitude, and for latitudes differing much from 40° they may be several minutes out.

March–April, 1901.

Phases of the Moon, P. S. T.

Full Moon . . .	March 5,	12ʰ 4ᵐ	A. M.
Last Quarter . . .	March 13,	5 6	
New Moon . . .	March 20,	4 53	
First Quarter . . .	March 26,	8 39	P. M.
Full Moon . . .	April 3,	5 20	
Last Quarter . . .	April 11,	7 57	
New Moon . . .	April 18,	1 37	
First Quarter . . .	April 25,	8 15	A. M.

The Sun.

1901.	R. A.	Declination.	Rises.	Transits.	Sets.
Mar. 1,	22ʰ 47ᵐ	− 7° 44′	6ʰ 39ᵐ A. M.	12ʰ 13ᵐ P. M.	5ʰ 47ᵐ P. M.
11,	23 24	− 3 52	6 23	12 10	5 57
21,	0 1	+ 0 5	6 7	12 7	6 7
31,	0 37	+ 4 0	5 51	12 4	6 17
Apr. 10,	1 14	+ 7 48	5 35	12 1	6 27
20,	1 51	+ 11 22	5 20	11 59 A. M.	6 38
30,	2 28	+ 14 39	5 7	11 57	6 47

Mercury.

Mar. 1,	23 23	− 0 20	6 49 A. M.	12 48 P. M.	6 47 P. M.
11,	22 52	− 3 51	5 51	11 38 A. M.	5 25
21,	22 38	− 7 45	5 11	10 45	4 19
31,	22 58	− 7 56	4 52	10 25	3 58
Apr. 10,	23 38	− 4 57	4 43	10 26	4 9
20,	0 30	+ 0 25	4 38	10 39	4 40
30,	1 32	+ 7 32	4 35	11 1	5 27

Venus.

Mar. 1,	21 50	− 14 18	6 6 A. M.	11 17 A. M.	4 28 P. M.
11,	22 38	− 10 4	5 58	11 24	4 50
21,	23 25	− 5 23	5 49	11 31	5 13
31,	0 10	− 0 28	5 40	11 38	5 36
Apr. 10,	0 56	+ 4 31	5 29	11 44	5 59
20,	1 42	+ 9 20	5 18	11 50	6 22
30,	2 29	+ 13 47	5 11	11 58	6 45

MARS.

1901.	R. A.	Declination.	Rises.	Transits.	Sets.
Mar. 1,	10 15	+15 28	4 44 P.M.	11 38 P.M.	6 32 A.M.
11,	10 1	+16 26	3 48	10 45	5 42
21,	9 51	+16 55	2 57	9 56	4 55
31,	9 46	+16 54	2 13	9 12	4 11
Apr. 10,	9 46	+16 28	1 36	8 33	3 30
20,	9 51	+15 41	1 4	7 58	2 52
30,	9 59	+14 36	12 37	7 27	2 17

JUPITER.

Mar. 1,	18 34	—22 59	3 23 A.M.	8 0 A.M.	12 37 P.M.
Apr. 1,	18 51	—22 44	1 37	6 15	10 53 A.M.
May 1,	18 57	—22 39	11 44 P.M.	4 23	9 2

SATURN.

Mar. 1,	19 0	—22 10	3 46 A.M.	8 27 A.M.	1 8 P.M.
Apr. 1,	19 9	—21 58	1 52	6 33	11 14 A.M.
May 1,	19 11	—21 55	11 56 P.M.	4 37	9 18

URANUS.

Mar. 1,	17 2	—22 47	1 51 A.M.	6 29 A.M.	11 7 A.M.
Apr. 1,	17 3	—22 49	11 49 P.M.	4 27	9 6
May 1,	17 0	—22 45	9 48	2 26	7 4

NEPTUNE.

Mar. 1,	5 45	+22 11	11 49 A.M.	7 9 P.M.	2 29 A.M.
Apr. 1,	5 45	+22 13	9 48	5 8	12 28
May 1,	5 48	+22 15	7 53	3 13	10 33 P.M.

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off left-hand limb as seen in an inverting telescope.)

I, D, Mar.	3,	3^h 11^m A.M.	I, D, Apr.	2,	5^h 5^m A.M.
I, D,	10,	5 5	I, D,	3,	11 43 P.M.
II, D,	11,	1 29	III, D,	5,	2 0 A.M.
II, D,	18,	4 2	III, R,	5,	4 41
I, D,	19,	1 27	I, D,	11,	1 37
I, D,	26,	3 21	II, D,	12,	12 58
III, R,	29,	12 42	I, D,	18,	3 30
			II, D,	19,	3 31
			I, D,	25,	5 24
			I, D,	26,	11 53 P.M.
			IV, D,	30,	11 15
			IV, R,	31,	12 1 A.M.

NOTE ON THE TIME OF RISING OR SETTING OF THE MOON.

By Sidney D. Townley.

Professor Young, in the 1898 edition of his "General Astronomy," added a method of computing the time of rising or setting of the Moon, (page 94, article 131). Since the method involves a transformation from sidereal to mean solar time I have found it less convenient than the following: Estimate as nearly as possible the Greenwich time of moonrise or moonset and take the Moon's Declination from the Ephemeris for that time. Compute the hour-angle with this value of the Declination using a zenith-distance of 90°. This hour-angle, corrected for the motion of the Moon in Right Ascension and for the gain of sidereal on mean solar time, subtracted from or added to the mean time of the Moon's transit (American Ephemeris, pages 408 to 415) gives the time of rising or setting. The correction to the hour-angle is easily obtained by multiplying the hour-angle by the "change per hour," found in the column adjacent to that of the mean time of transit. If the first estimate of the Moon's Declination is not very close, then the computation must be repeated.

The correction for semi-diameter, refraction and parallax is always small. Assuming the horizontal refraction to be 35′ then this correction in medium latitudes will range from two-tenths to one minute, depending upon the value of the parallax. For most purposes it is quite sufficient to assume five-tenths of a minute for this correction, which is to be added to the time of rising and subtracted from the time of setting.

If a series of values of risings and settings are to be computed for any particular place, then it will be convenient to construct a table for this correction. Likewise, a table for hour-angles ($Z = 90°$) may be computed, with the Declination of the Moon as the argument.

(THIRTY-EIGHTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to M. Michel Giacobini, of the Nice Observatory, for his discovery of an unexpected comet on January 31, 1900.

The Committee on the Comet-Medal,

W. W. CAMPBELL,
W. M. PIERSON,
1901, January 14. CHAS. BURCKHALTER.

(THIRTY-NINTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to A. BORRELLY, Adjunct Astronomer in the Observatory, Marseilles, France, for his discovery of an unexpected comet on July 23, 1900.

The Committee on the Comet-Medal,

W. W. CAMPBELL,
W. M. PIERSON,
CHAS. BURCKHALTER.

NOTE. — This comet was independently discovered on the same night (July 23), but about five hours later in absolute time, by W. R. BROOKS, of Geneva, New York; and the discovery was regularly and promptly announced.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

APPOINTMENT OF PROFESSOR W. W. CAMPBELL AS DIRECTOR OF THE LICK OBSERVATORY.

The Board of Regents of the University of California, at a meeting held in San Francisco on December 11, 1900, by unanimous vote, elected Professor W. W. CAMPBELL to be Director of the Lick Observatory.

As evidence of the general approval with which this action of the Board of Regents meets, we quote the following sentences from the note by Director GEO. E. HALE, of the Yerkes Observatory, in the December (1900) number of the *Astrophysical Journal*:—

"The wisdom of this choice will be apparent to every one familiar with the circumstances of the case. The task which falls to the successor of Professor KEELER is no easy one, a fact which the Observatory Committee fully appreciated. They accordingly deferred action until the opinions of many eminent astronomers in this country and abroad could be secured. The replies, almost without exception, named Professor CAMPBELL as first choice. It is evident that his remarkable success as an investigator, his tireless energy, and his ability to direct the work of others are widely known and appreciated. It is a pleasure to extend congratulations to the President and Regents of the University of California for the wise manner in which the appointment was made, to the Lick Observatory for its bright prospects under such leadership. and to Professor CAMPBELL himself for the wider opportunity in the prosecution of his researches which he will now enjoy."

THE D. O. MILLS EXPEDITION TO THE SOUTHERN HEMISPHERE.

In the past five years, numerous references have been made in these *Publications* to the Mills spectrograph, an instrument presented to the Lick Observatory by the Hon. D. O. MILLS. This instrument, attached to the eye-end of the 36-inch refractor, has been used three nights per week in determining the veloci-

* Lick Astronomical Department of the University of California.

ties of the brighter stars in the line of sight. The main purpose of the investigation is to secure observational data from which to determine the speed and direction of motion of the solar system through space. In addition, it was hoped that the data secured would throw light on many of the fundamental questions relating to the constitution of the stellar universe, such as the distances of the stars, their grouping in families, etc. The results thus far obtained have shown that the field is one of unexpected richness. It may well occupy the attention, for an indefinite period, of the large number of observers and institutions now engaging in its development. Thus far we have secured observations of about 325 stars situated between the North Pole and 30° South Declination. The region south of 30° cannot be observed from Mt. Hamilton; yet the necessity of obtaining data somewhat uniformly distributed over the entire sky will be apparent to all who have considered the difficulties in the way of a satisfactory determination of the elements of the solar motion.

For three or four years past I have hoped that, when the proper time came, this work could be extended to the South Pole, by means of a suitably equipped observing-station in the Southern Hemisphere. The rapid progress of the work at Mt. Hamilton made it desirable that the southern programme should be taken up at once. With the approval and indorsement of President WHEELER of this university, I laid my plans before Mr. MILLS, in November; and he at once stated that it would give him great pleasure to supply the funds to defray the entire expenses of the expedition. It is not often that an observatory receives such liberal support, in an ideal manner, for an ideal purpose. The Lick Observatory makes grateful acknowledgment of its indebtedness to Mr. MILLS'S generosity at the present time and in the past.

In the next number of these *Publications* I hope to be able to give in some detail the plans of the expedition.

The observing-station will be selected with great care, probably in Chile or west of the Blue Mountains in Australia. In addition to a large proportion of clear nights, I should like to be assured of low relative humidity, a small range of night temperatures, little or no south night-winds, and fair accessibility.

W. W. CAMPBELL.

THE CROCKER ECLIPSE EXPEDITION TO SUMATRA.

The total solar eclipse of May 17, 1901, is one of the most important astronomical events of recent times, on account of its long duration. The path of totality crosses the islands of Mauritius, Sumatra, Borneo, Celebes, Ceram, New Guinea, etc. Its duration reaches a maximum of six and one-half minutes on the west coast of Sumatra. This is, I believe, the longest duration for any *observable* eclipse in the last half-century, since serious eclipse-work began; though eclipses of slightly longer duration have occurred on the ocean. It is a fortunate circumstance that on the west coast of Sumatra the eclipse occurs near noon, (at twenty-two minutes after local mean noon,) with the Sun only 21° from the zenith. While the weather conditions along the line are not of the best, yet they appear to be as promising in western Sumatra as in any of the islands farther east. This is likewise the region most accessible for observing-parties.

The Lick Observatory has had it in mind to prepare extensively for the suitable observation of this important eclipse. However, the reduced size of our observing-staff, and the pressure of work on the *Eros* campaign, made it impossible to plan for the expedition, until the middle of January.

It is a pleasure to announce that the Lick Observatory is again indebted to the generosity of WILLIAM H. CROCKER, Esq., who has offered, by virtue of his interest in the work, to defray all the expenses of an expedition to Sumatra.

The expedition plans to leave San Francisco on February 19th, traveling via Yokohama, Hong Kong, and Singapore. It should reach Padang, Sumatra, about April 10th. Assistant Astronomer C. D. PERRINE will be in charge, accompanied by one assistant from here. He will plan to secure the services of ten or twelve local assistants, during the week of the eclipse, from among the foreigners in Padang.

The long duration makes this the occasion for investigations on the corona, rather than on the edge of the Sun. It also affords unusual advantages for a search for unknown objects in the Sun's vicinity,—such as the planet, or planets, *Vulcan*. Accordingly, the work will be largely limited to these lines. I regret that we shall not be able to spare from the Observatory a spectroscopic observer; but I shall send one or two simple spectrographs along with the party, suitable for recording the coronal spectrum, hoping that the pressure of other work will not prevent their use. W. W. CAMPBELL.

A LIST OF EIGHT NEW SPECTROSCOPIC BINARIES.

The following eight spectroscopic binaries, discovered with the Mills spectrograph, are additional to the seventeen already announced in these *Publications* :—

12 Persei ($\alpha = 2^h\ 36^m$; $\delta = +\ 39^\circ\ 46'$).

The binary character of this star was discovered in January, from the second spectrogram. The spectra of both components are visible on the first three plates, and are not very unlike. On the last plate the two spectra appear to be coincident.

Date.			Velocities.		
1899	Dec.	19	-42^{km}	and	$\pm\ 0^{km}$
1900	Jan.	22	$-\ 3$	"	$-\ 54$
	Jan.	26	$-\ 11$	"	$-\ 43$
	Aug.	7		$-\ 27$	

The velocity of the system is about —— 25 km per second.

ξ Ursæ majoris ($\alpha = 11^h\ 13^m$; $\delta = +\ 32^\circ\ 06'$).

The principal component of this well-known double star has a variable velocity in the line of sight. *ξ Ursæ majoris* is therefore a triple system. The visible system is interesting historically, as having been the first one to show orbital motion, the two visible components forming a close and rapidly revolving system ($a = 2''.5$, $P = 60$ years). It has been observed with the micrometer very frequently since the beginning of the century, but no evidences of perturbative influences have been revealed by the measurements.

Date.			Velocity.
1897	Feb.	23	$-\ 8.4^{km}$
	April	8	$-\ 15$
1899	Feb.	22	$-\ 11.5$
	April	5	$-\ 14.1$
1900	Feb.	26	$-\ 21.9$
	Mar.	9	$-\ 18.4$
	Mar.	12	$-\ 19$
	Mar.	14	$-\ 21.6$
	Mar.	20	$-\ 20$
	May	8	$-\ 18$

The variable velocity was discovered early in March, from the fifth plate.

The spectrograms obtained in 1897 are rather poor, and will probably not be needed in the final discussion of the motion.

93 Leonis ($\alpha = 11^h\,43^m$; $\delta = +20^\circ\,46'$).

The first two plates of this star were underexposed, but the discordance of eight kilometers afforded strong suspicion of its variable velocity. Two late plates confirmed the fact of its variability.

Date.		Velocity.
1900	Jan. 10	$+22^{km}$
	Jan. 16	$+14 \pm$
	April 9	-16
	May 14	$+16$

d Boötis ($\alpha = 14^h\,06^m$; $\delta = +25^\circ\,34'$).

Date.		Velocity.
1900	Mar. 27	$+79^{km}$
	April 4	$+3$
	April 9	$+11$
	April 17	$+60 \pm$

The variable velocity was discovered from the second plate.

β Scuti ($\alpha = 18^h\,42^m$; $\delta = -4^\circ\,51'$).

Date.		Velocity.
1899	May 15	-17^{km}
	June 11	-11
1900	April 17	-28
	April 23	-29
	May 14	-32
	July 18	-31

The variable velocity was discovered from the third plate.

113 Herculis ($\alpha = 18^h\,50^m$; $\delta = +22^\circ\,32'$).

Date.		Velocity.
1900	June 5	-35^{km}
	July 9	-21
	July 17	-19
	July 31	-16

The variation was discovered from the second plate.

2 Scuti ($\alpha = 18^h\,37^m$; $\delta = -9^\circ\,09'$).

Date.		Velocity.
1899	June 14	-49^{km}
	June 19	-50
	July 3	-45
1900	June 27	-40
	July 3	-38
	Aug. 1	-49
	Aug. 12	-38

The lines in this star's spectrum are rather broad, and cannot be measured very accurately. In addition, the third plate was underexposed; and the range of five kilometers in the approximate results for the first three plates afforded only a slight suspicion of variability. Its reality was established from the fourth plate.

η *Andromedæ* ($\alpha = 0^h\ 52^m$; $\delta = +22°\ 52'$).

Two components seem to be visible in the spectrograms of this star. The results for the principal components are:—

Date.		Velocity.
1899	Oct. 24	-25^{km}
	Oct. 31	-26
1900	July 24	-12
	Aug. 8	$+2$
	Sept. 9	-2

The two component spectra appear to be practically coincident in the spectrogram of 1900, July 24th.

Mr. WRIGHT was in charge of the work with the Mills spectrograph during my connection with the Crocker Eclipse Expedition to Georgia, from March to late in July. While following the regular programme of observation, he detected the variable velocities of the stars ξ *Ursæ majoris*, *d Boötis*, β *Scuti*, *113 Herculis*, and *2 Scuti*, as described above; and the credit for these five discoveries belongs to him. W. W. CAMPBELL.

SOLAR PARALLAX OBSERVATIONS MADE AT THE LICK OBSERVATORY.

Observations of the planet *Eros* and of reference-stars, for determining the solar parallax, have been secured at the Lick Observatory, as follows:—

Astronomer R. H. TUCKER, assisted by Mr. R. T. CRAWFORD, Fellow in Astronomy, obtained two meridian-circle observations of each of the 319 reference-stars forming the first list in the Bulletin (No. 4) of the Conférence Astrophotographique Internationale. There have been made 1,100 observations in completing this list, including fundamental and circumpolar stars and nadirs. The reductions were completed, and the manuscript giving the results was ready for the printer, on December 21, 1900.

Mr. TUCKER has secured two observations of each of the 352 stars forming the second Conférence list. The completion of the second list has required about one thousand observations. The observations are all reduced to apparent place, and the mean-place reductions alone remain to be made. Mr. CRAWFORD assisted on the first one-fifth of the programme.

Astronomer W. J. HUSSEY secured micrometer-measures of *Eros* with the 36-inch refractor, on eleven nights, from October 25th to December 12th. Forty-four complete observations were secured at large hour-angles east of the meridian, and fifty-five at large hour-angles west. One observation is composed of

4 micrometer-differences in Declination,
8 " " in Right Ascension,
4 " " in Declination,
involving sixteen micrometer-settings.

Assistant Astronomer R. G. AITKEN obtained micrometer-measures of the planet with the 36-inch refractor on fifteen nights between October 21st and January 1st. He obtained forty-one complete observations at large eastern hour-angles, and forty-two at large western. Each observation is composed of

3 micrometer-differences in Declination,
10 " " in Right Ascension,
3 " " in Declination,
10 " " in Right Ascension,
3 " " in Declination,
involving twenty-nine micrometer-settings.

With the Crossley reflector, Assistant Astronomer C. D. PERRINE, assisted by H. K. PALMER, Fellow in Astronomy, secured meridian-observations of *Eros* on sixty-one nights, between September 16th and January 18th. These are photographic, on 332 plates, five sets of images on each plate. Three hundred plates for parallax were obtained at large eastern hour-angles on thirty-four nights, and 220 plates at large western hour-angles on twenty-six nights. Many of the images on these plates are poor, and unavoidably so, on account of the defective mounting of the telescope. The great majority, however, are excellent, and only the best will be needed for measurement. Arrangements for measuring the plates, made with Professor REES, Director of Columbia University Observatory, referred to in the last number of these *Publications*, leave no doubt that all the merits of these photographs will be utilized. No department of Astronomy is more promising, or is developing more rapidly, than that relating to the accurate determinations of star-positions from photographic plates. Columbia University Observatory has had a very extensive experience in this field, and is the only institution in this country with equipment and organization suitable for doing this work on a large scale.

Since the middle of December, the nights suitable for making *Eros* observations have been unusually few, even for winter months.

W. W. CAMPBELL.

1901, January 30.

A GIFT TO THE LICK OBSERVATORY.

The Committee of the National Academy of Sciences in charge of the Henry Draper Fund (for promoting research in astronomical physics) have made a grant of five hundred dollars to the Lick Observatory, to provide lenses, prisms, slit, materials, etc., for the construction of a thoroughly modern one-prism spectrograph.

The spectrographic work on faint spectra at this Observatory was done for several years with the original visual spectroscope, provided with photographic lenses. This was unsatisfactory, on account of the very large flexure effects during long exposures. Later, our one-prism spectrography has been done with a wooden-mounted instrument. The need of a first-class one-prism instrument has long been felt; and the generous gift from the Draper Fund will provide for its construction in the near future.

1901, January 30. W. W. CAMPBELL.

COMET NOTES.

Only three comets were discovered in the year 1900, all unexpected.

Comet *a* was discovered by M. GIACOBINI at Nice, on January 31, 1900. It was approaching the Sun rapidly when discovered, and in a few weeks was lost to observation, only reappearing on the other side of the Sun toward the end of May. The last observation made at this observatory was on July 22d. The comet's path was sensibly parabolic.

Comet *b* was discovered on July 23d by M. BORRELLY, at Marseilles, and independently by Dr. BROOKS, at Geneva, N. Y., a few hours later on the same night. It was a conspicuous object in a telescope of moderate aperture for several weeks, and at its brightest, was visible to the naked eye. A number of photographs of it were secured at the Lick Observatory, some of which will be reproduced in a future issue of these *Publications*. The comet was last seen with the 36-inch refractor on December 22, 1900, at which time it was estimated as being about equal to a 15th-magnitude star in brightness. Unfavorable weather has prevented any subsequent examination. It was found so close to its ephemeris position on the date mentioned that its path cannot vary sensibly from a parabola.

Comet *c* 1900, discovered by M. GIACOBINI, at Nice, on the night of December 20th, is still under observation, though it is already so faint as to be out of reach of small telescopes. The first three observations made at Mt. Hamilton, and the orbit based on them, will be found among the astronomical telegrams in this number. The elements resemble those of Comet 1857 IV sufficiently to indicate that the two comets may belong to the same family. If so, Comet *c* may prove to be a periodic comet of long period; but further observations are needed before this point can be decided.

FINLAY'S periodic comet, which returned to perihelion early in the year 1900, was not detected, owing probably to its unfavorable position. According to the calculations of M. SCHULHOF, it will be much more favorably placed in 1906, when it will approach within twenty million miles of the Earth.

BARNARD'S comet of 1884 also escaped detection, as at its previous return in 1890 and 1895.

E. SWIFT'S comet of 1894, which may be identical with DE VICO'S comet of 1844, returns to perihelion on February 13th of the present year, and may perhaps be found after perihelion passage. So far it has not been seen, though it, as well as BARNARD'S comet, was carefully looked for by Mr. PERRINE with the 36-inch refractor.

There are several other interesting periodic comets that may be observed during the present year, viz: BRORSEN'S, which should return to perihelion this month; DENNING'S (1894), ENCKE'S, and BROOKS'S of 1886, whose perihelion passage occur in August and September, 1901, and January, 1902, respectively.

Mr. DENNING, in *Knowledge*, has called attention to the curious fact that during the century just closed, one or more large naked-eye comets were seen at intervals of about 19½ years — in

1823, 1843, 1862, and 1881. Those who are interested in this line of work will sincerely hope that later writers may be able to add the year 1901 to this list. R. G. AITKEN.

ASTRONOMICAL TELEGRAMS.

(Translations.)

CAMBRIDGE, MASS., Dec. 8, 1900.
To W. W. CAMPBELL: (Received 3:05 P.M.)

DOUGLAS, of the Lowell Observatory, telegraphed last night that a projection was seen on the north edge of *Icarium Mare** that lasted seventy minutes. (Signed) E. C. PICKERING.

BOSTON, MASS, Dec. 24, 1900.
To Lick Observatory: (Received 9:20 A.M.)

A comet was discovered by M. GIACOBINI at Nice, on December 20.313, G. M. T., in R. A. $22^h\ 32^m$, and Decl. — $22°\ 0'$ (approximate position). Its daily motion is + $1°30'$ in R. A., and $-8'$ in Decl. (Signed) JOHN RITCHIE, JR.

LICK OBSERVATORY, Mt. Hamilton, Cal.,
To Harvard College Observatory, Dec. 24, 1900.
Cambridge, Mass., (Sent 8:20 P.M.)
To Students' Observatory, Berkeley, Cal.:

Comet Giacobini was observed by R. G. AITKEN on December 24.6022, G. M. T., in R. A. $22^h\ 59^m\ 10^s.2$; Decl. — $22°\ 44'\ 41''$
(Signed) W. W. CAMPBELL.

CAMBRIDGE, MASS., Dec. 25, 1900.
To Lick Observatory.: (Received 8:30 A.M., Dec. 26.)

Kiel cables that Comet *c* (GIACOBINI) was observed at Nice on Dec. 24.271, G. M. T., in R. A. $22^h\ 57^m$; Decl. — $22°\ 45'$. Approximate position. (Signed) EDWARD C. PICKERING.

LICK OBSERVATORY, Mt. Hamilton, Cal.,
To Harvard College Observatory, Dec. 27, 1900.
Cambridge, Mass., (Sent 1:57 P.M.)
To Student's Observatory, Berkeley Cal.:

Comet Giacobini was observed by R. G. AITKEN on December 26.6280 in R. A. $23^h\ 11^m\ 23^s.6$; Decl. — $22°\ 57'\ 59''$.
(Signed) W. W. CAMPBELL.

* *Icarium Mare* is in Martian Longitude 320° - 345° and Martian Latitude + 30°±.

LICK OBSERVATORY, Mt. Hamilton, Cal.,
To Harvard Observatory, Dec 28, 1900.
Cambridge, Mass., (Sent 10:55 P.M.)
To Student's Observatory, Berkeley, Cal.:

Comet Giacobini was observed by R. G. AITKEN on Decem-28.6198 in R. A. $23^h\ 23^m\ 18^s.5$; Decl. $-\ 23^\circ\ 7'\ 27''$.

(Signed) W. W. CAMPBELL.

LICK OBSERVATORY, Mt. Hamilton, Cal.,
To Harvard College Observatory, Dec. 31, 1900.
Cambridge, Mass.: (Sent 4:15 P.M.)

From the Lick Observatory observations of December 24, 26, and 28, elements and ephemeris [here omitted] of Comet *c* 1900 (GIACOBINI) were computed by R. G. AITKEN as follows:—

$$T = \text{December } 1.41 \text{ G. M. T.}$$

$$\left.\begin{array}{l} \omega = 175^\circ\ 54' \\ \Omega = 192\ \ 39 \\ i = \ \ 31\ \ \ 1 \end{array}\right\} 1900.0$$

$$\text{natural } q = 0.9769$$

(Signed) W. W. CAMPBELL.

[The Lick Observatory positions of Comet *c* for the dates December 24th and 28th, as printed in *Science Observer, Special Circular, No. 128*, are slightly in error owing to a mistranslation in each telegram of the cipher-word giving the seconds and tenths of seconds of R. A., the seconds of N. P. D., and the fourth decimal of the date. Both messages were sent correctly from the Lick Observatory, and were transmitted correctly by the Western Union Telegraph Company in San José. The correct translations are printed above.]

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in carrying out the work of this department. Communications of general interest will be gladly received, and may be sent to SIDNEY D. TOWNLEY, 2023 Bancroft Way, Berkeley, California.

Dr. LEWIS SWIFT has disposed of his astronomical equipment to the Pasadena and Mount Lowe Railway. The instruments are to remain on Echo Mountain, and Professor E. L. LARKIN is now director of the observatory.

The oft-recurring discussion concerning the management of the United States Naval Observatory is again before the public. The discussion was precipitated by the publication of the report of the Superintendent of the United States Naval Observatory for the fiscal year ending June 30, 1900. In it Superintendent DAVIS takes occasion to criticise rather severely the actions and report of the Board of Visitors appointed by Secretary LONG in 1899. Replies to these criticisms have appeared as editorials and communications in *Science*, January 4th, 11th, and 18th. The discussion has now reached such a point that its continuation will be productive of very little good. A great many astronomers think the present management of the Observatory is fundamentally wrong. It is to be hoped that they will soon make a determined effort to have the Observatory reorganized, or else keep still and give the new staff a chance to show what it can do.

Volume XVIII of the *Publications of the National Observatory of the Argentine Republic* has been received recently. It is a continuation of the Southern Durchmusterung, and contains a catalogue of 149,447 stars, being all the stars down to the tenth magnitude in the zone 42° to 52° South Declination. It is a matter of congratulation that Dr. THOME, notwithstanding many difficulties, financial and others, has been able to bring the third part of this great work to completion.

At the annual public meeting of the Paris Açademy of Sciences, held on December 17, 1900, the following prizes were awarded for astronomical work: The Lalande prize, to M. GIACOBINI, of Nice, for his work on comets; the Damoiseau prize, to M. J. VON HEPPERGER, for his work on the influence of the planets on comets; the Valz prize, to M. l'Abbé VERSCHAFFEL, for work done at the Abbadia Observatory; and the Janssen prize, to Professor BARNARD, for the discovery of the fifth satellite of Jupiter.

The *Astrophysical Journal* for December contains an important article, by Professor EDWIN B. FROST, on the spectroscopic and photographic work of the Yerkes Eclipse Expedition (May, 1900). The conclusions reached are summarized as follows:—

"The experience, principally of Sir NORMAN LOCKYER and Mr. J. EVERSHED, is confirmed, that useful results may be obtained, without much risk of failure, by the employment of the simple objective-prism camera.

"It is shown that the concave grating, used direct, without intervention of mirrors or lenses, will furnish sufficiently bright images of the flash spectra, and probably of the corona, for useful measurement and discussion.

"It appears that spectra photographed with such instruments just before or after totality (within about thirty seconds of the times of contact), yield quite as valuable results as those taken at the precise instants of contact.

"It is demonstrated that the stronger dark-lines of the solar spectrum are in a large proportion reversed in a narrow stratum at the base of the chromosphere, and the evidence indicates that this is equally true of the fainter lines.

"The differences in intensities of the bright and dark lines are chiefly due to an increase in the intensities of the former, especially for such elements as strontium, rather than to a decrease in the intensities of the latter.

"The chemical origin of the dark lines which are reversed is found in elements which are among those most numerously represented in the spectrum. This tends to show that the reversal is not an inherent peculiarity of special elements, but rather a phenomenon of lines in general."

Continuing the plan inaugurated last year letters were recently sent to the directors of the observatories of the Pacific Coast, asking for a statement of the work accomplished during 1900. From the answers received the following accounts have been written:—

CHABOT OBSERVATORY.—Instruction in connection with the schools of the city of Oakland has continued, as in former years, to be the chief work of this Observatory. A lecture-hall, to be used for school and general educational purposes, has recently been erected adjoining and communicating with the Observatory. The hall is about seventy-five feet long and provided with six hundred opera-chairs. Very complete arrangements have been made for heat, ventilation, and light. Arc-light and solar-projection lanterns have been provided for the use of lecturers. Considerable of Mr. BURCKHALTER's time during 1900 was taken up in connection with the eclipse of May 28th, which he successfully observed at Siloam, Georgia. An account of his expedition, together with some reproductions of the photographs taken, may be found in No. 75 of these *Publications.*

INTERNATIONAL LATITUDE OBSERVATORY.—Latitude observations were continued at the Observatory in Ukiah without interruption during 1900. Dr. SCHLESINGER'S report of the work accomplished is as follows:—

"The programme of the International Geodetic Association for observing Variations of Latitude has been continued without modification at this station, as well as at the five others, throughout 1900. An account of the programme is to be found in No. 71 of these *Publications.* Below is given a summary of the observations made here during the year:—

"I. *Observations for Latitude proper.*—The following table shows the number of nights and the number of pairs observed in each month:—

January . . .	15 nights . . .	179 pairs
February . .	13 " . . .	168 "
March	14 " . . .	182 "
April	11 " . . .	154 "
May	18 " . . .	208 "
June	13 " . . .	169 "
July	15 " . . .	209 "
August	14 " . . .	188 "
September . .	14 " . . .	166 "
October . . .	14 " . . .	181 "
November . .	13 " . . .	123 "
December . .	14 " . . .	176 "
Totals . .	168 nights	2,103 pairs

"These numbers include 'refraction pairs' (about twenty per cent. of the total), which are not used for determining the latitude, but to detect possible anomalies in the refraction.

"II. *Observations for the control of the position of the instrument.*—This work has been much simplified by the use of the meridian-marks. These having once been set in place, the azimuths are held in excellent control. Although observations were frequently made to test the adjustment of the marks, the latter might have been assumed correct throughout the entire year without incurring any appreciable error in the latitude. Similarly, the collimation and lateral flexure have remained sensibly constant; the former varied only $0^s.10$ from its mean value during the year.

"III. *Observations for values of the level spaces.*—Nine tests were made for each of the two levels with which the zenith-telescope is provided. These tests are based upon the star observations by a method described on another page of this publication.

"IV. *Observations for micrometer value.*—Two series of observations for this purpose were executed; one on circumpolar stars near elongation, the other upon stars in the *Pleiades* whose differences of declinations have been well determined, especially by BESSEL, ELKIN, and JACOBY.

"V. *Observations for screw-errors.*—The progressive errors of the screw were determined by suspending a vertical scale at some distance from the telescope and then determining the errors of the scale and the screw simultaneously. A more detailed account of this investigation will be given later.

"A definitive reduction of the observations made at all the stations up to 31st December, 1900, is now in progress at Potsdam, and will shortly be published. A preliminary reduction, already made, gives promise of unprecedented accuracy in the determination of the path of the Earth's pole of rotation upon its surface."

LICK OBSERVATORY.—Through the "Notices from the Lick Observatory," the readers of the *Publications* are kept well informed concerning the work carried on in that institution. During the past year, in addition to the regular work of the Observatory, an eclipse expedition to Georgia was undertaken by Dr. CAMPBELL and Mr. PERRINE. These two observers were assisted by about a dozen volunteer workers, and a large programme of work was successfully carried out in the short time of totality. A general account of the expedition was printed in No. 75 of these *Publications*, and the more detailed account will be issued later by the Observatory.

Professor KEELER's second annual report, written only a few weeks before his death, has recently been published in President WHEELER's biennial report to the Governor of the State. The report contains, in some detail, an account of the work being carried out with the various instruments. Extracts, concerning the work with the two largest instruments, are given below. "About half the time of the 36-inch equatorial is devoted to spectroscopic determinations of the motions of stars in the line of sight, with the aid of the Mills spectrograph. This department of the scientific work of the Observatory, which is probably as important as any work that can be done at the present time with a large telescope, has been admirably systematized by Dr. CAMPBELL, who is assisted in the observations and reductions by Mr. WRIGHT. The probable error of a single determination is only about 0.25 km. for the best stars, a degree of accuracy which has never before been reached in such measurements. A correcting-lens, which is placed in the cone of rays from the 36-inch objective, and which changes the chromatic aberration of the telescope so as to adapt it to photographic work, has added somewhat to the accuracy and very much to the convenience of the observations. . . . For the remaining half of the time the telescope has been used for micrometric work by Mr. HUSSEY, Mr. PERRINE, and Mr. AITKEN, and occasionally by other observers. Series of observations of the satellites of *Neptune* and *Mars* have been made by Mr. HUSSEY; of the satellites of *Neptune* and *Uranus* by Mr. AITKEN. A hundred and fifty sets of measures of planetary nebulæ, for parallax, and a set of measures for determining a possible refractive effect on stars by the head of SWIFT's comet, have been made by Mr. PERRINE. . . . . Observation with the Crossley reflector is subject to more limitations than observations with the other instrument. Work cannot be pursued on moonlight nights, in slightly foggy, or even in damp weather. Nevertheless, about seventy photographs have been made of forty different nebulæ and star-clusters, mostly with long exposures of from three four hours each, and from the most interesting of these, positive enlargements have been made on glass. The definition of these photographs, and the amount of detail shown by them, are surprising. Many new features are shown, and some general conclusions of the highest interest have already been drawn. From one to sixteen new nebulæ have been found on nearly every plate exposed, and I have estimated that the number of new nebulæ in the sky, within reach of the Crossley reflector, may be something like 120,000."

MOUNT LOWE OBSERVATORY—Dr. SWIFT, owing to advanced age, did but little astronomical work during 1900. As stated in another place in these notes, Dr. SWIFT has disposed of his astronomical outfit, and Professor EDGAR L. LARKIN, formerly Director of the Knox College Observatory, Galesburg, Ill., is now Director of the Mount Lowe Observatory. Professor LARKIN took charge of the observatory January 1, 1901, and writes that he is now engaged in reorganizing the observatory, making necessary repairs, etc. When all of the necessary changes are made he expects to give his time to spectroscopic work, mostly upon the Sun.

NAVAL OBSERVATORY.—Mare Island.—Lieutenant GUY W. BROWN, U. S. Navy, writes that owing to many duties as a naval officer, no astronomical work other than that of maintaining the time-service of the Pacific Coast was attempted at Mare Island.

STUDENTS' OBSERVATORY.—The work at the Students' Observatory, Berkeley, is nearly all in the line of instruction, and the time of the members of the staff is given to directing and supervising the work of students rather than to research work. During the last two years a much closer relation between the Berkeley and Lick Astronomical Departments of the University has been established. It has been Professor LEUSCHNER's ambition to build up here, in connection with the Lick Observatory, a thorough School of Astronomy. During the past year a comprehensive course of study, both undergraduate and graduate, has been outlined, and a special announcement to students is now being printed. We hope to give a more detailed account of this in the next number of these *Publications*. During the first term of 1900, the total enrollment in astronomical courses was 130, and during the second term 120. Among the special lines of work carried out during the past year, the following may be mentioned: Computation, by Professor LEUSCHNER and Miss HOBE, of the orbit of a faint asteroid discovered by Professor KEELER with the Crossley Reflector, June 28, 1900; computation of the elements of the Crossley asteroid 1899 FD, by Mr. PALMER and Mr. PHIPPS; notes on the computation of preliminary orbits (*A. N.* No. 3669) by Mr. SPRAGUE; adaptation to long intervals of VON OPPOLZERS' method of computing comet orbits from four observations, by Mr. KUNO.

UNITED STATES COAST AND GEODETIC SURVEY OBSERVATORY.—This observatory, situated in the Presidio Reservation, San Francisco, and provided with a transit and a zenith-telescope, is used as a longitude base for the determination of new stations by telegraphic time-signals and for practice of observers. Captain AUG. F. ROGERS, Assistant in Coast Survey, and in charge of the observatory, writes, however, that no new determinations were made during 1900.

Minutes of the Meeting of the Board of Directors, held in the Rooms of the Society, January 26, 1901, at 7:30 p. m.

Mr. Burckhalter presided. A quorum was present. The minutes of the last meeting were approved. The following members were duly elected:—

List of Members Elected January 26, 1901.

Mr. B. A. Baird	U. S. Coast and Geodetic Survey, P.O. Box 2512, S.F., Cal.
Mr. C. F. De Mott	P. O. Box 400, Hempstead, Nassau Co., N. Y.
Mr. E. B. Leaming	Rooms 13 & 14, 4th floor, Mills Building, S. F., Cal.
Prof. A. O. Leuschner	2011 Bancroft Way, Berkeley, Cal.
Mr. C. E. Sanger	932 E St., San Diego, Cal.
Dr. Frank Schlesinger	Ukiah, Cal.
Mr. V. Stróyberg	Observatory, Copenhagen, Denmark.

Adjourned.

Minutes of the Meeting of the Astronomical Society of the Pacific, held in the Lecture Hall of the California Academy of Sciences, January 26, 1901, at 8 o'clock p. m.

Mr. Burckhalter presided. The minutes of the last meeting were approved.

The following papers were presented:—

1. The Determination of the Motion of the Solar System, from Observations with the Mills Spectrograph, by Prof. W. W. Campbell.
2. Planetary Phenomena for March and April, 1901, by Prof. M. McNeill.
3. A Method for Determining the Value of an Average Space of a Latitude-Level in Terms of a Micrometer-Turn, by Frank Schlesinger.

A committee to nominate a list of eleven Directors, and committee on Publication, to be voted for at the annual meeting, to be held on March 30th, was appointed as follows: Messrs. D. S. Richardson, (chairman), J. Costa, M. Mullany, C. F. A. Talbot, L. H. Pierson.

A committee to audit the accounts of the Treasurer, and to report at the annual meeting in March, was appointed as follows: Messrs. Wm. H. Lowden (chairman), O. von Geldern, F. H. McConnell.

The chairman then introduced Professor Campbell, the lecturer of the evening, who gave an account, illustrated by lantern-slides, of the progress of the work being done at the Lick Observatory on the determination of the Motion of the Solar System, from observations with the Mills Spectrograph.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. James E. Keeler* . . . . *President*
Mr. Charles Burckhalter . . . . *First Vice-President*
Miss R. O'Halloran, ... *Second Vice-President*
Mr. S. D. Townley . . . . *Third Vice-President*
Mr. C. D. Perrine, Mr. F. R. Ziel . . . . *Secretaries*
Mr. F. R. Ziel . . . . *Treasurer*

Board of Directors—Messrs. Burckhalter, Campbell, Dolbeer, Hill, Keeler,* Molera, Miss O'Halloran, Messrs. Perrine, Pierson, Townley, Ziel.

Finance Committee—Messrs. Pierson, Burckhalter, Hill.

Committee on Publication—Messrs. Aitken, Townley, von Geldern.

Library Committee—Mr. Townley, Miss O'Halloran, Miss Hobe.

Committee on the Comet-Medal—Messrs. Keeler * (*ex-officio*), Pierson, Burckhalter.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. Ruthven W. Pike.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. Francisco Rodriguez Rey.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.
(February, April, June, August, October, December.)

* Deceased.

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(1)

(2)

(3)

THE ZODIACAL LIGHT IN *PISCES*.

Lowell Observatory, Feb. 13, 1901.

Exposure times: (1) = $7^{m}.5$; (2) = 15^{m}; (3) = 30^{m}.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. XIII. SAN FRANCISCO, CALIFORNIA, APRIL 1, 1901. NO. 78.

PHOTOGRAPHS OF THE ZODIACAL LIGHT.

By A. E. DOUGLASS.

The accompanying photographs of the western zodiacal cone were made by the writer on February 13, 1901. The lens was made by ALVAN CLARK & SONS in 1899 especially for this purpose. It has the Fraunhofer curves. Its clear aperture is 0.9, inch and its focus 1.8 inches, a ratio of 1 : 2. The mounting used in this work is largely home-made, consisting of a powerful Seth Thomas clock-movement, working into a cog-wheel having 120 teeth, attached to an inverted altazimuth mounting belonging to a two-inch telescope.

Previous to February 13th a number of photographs had been obtained with this apparatus, by exposures of an hour or more. On that date, however, trials of short exposures were made with immediate success. It appears that when the Zodiacal Light is at its best, exposures of eight minutes are ample; at its worst, thirty minutes are required, as for the Gegenschein. Impressions of the Gegenschein have almost certainly been obtained, but more experimenting is necessary before successful prints can be made.

Trials of some eight or ten different developers have been made, with the result, thus far, that two may be used with safety, a fairly strong glycin developer and a hydrochinon developer with about twenty-five drops of bromide solution for every two ounces, and perhaps a few drops of a ten-per-cent. solution of yellow prussiate of potash. The development with the glycin may be carried on for almost any length of time without fogging, but it is largely finished in thirty minutes. The development in the hydrochinon may be continued for thirty minutes, or until the plate fogs. As far as the trials go, the glycin is slightly better than the hydrochinon.

The first negative obtained at this observatory, showing the Zodiacal Light, was on March 10, 1899. Many different lenses were tested, and a number of satisfactory negatives were obtained, of which one of the best was of the eastern cone, on October 7, 1899. This was reproduced in *Popular Astronomy*, No. 74, April, 1900. But the engraving did not by any means equal the photographic print. And, besides that, the original exposures before the present year were all made by hand-following. This tedious work was done nearly always by Mr. W. A. COGSHALL.

LOWELL OBSERVATORY,
FLAGSTAFF, ARIZONA, March 11, 1901.

PHOTOGRAPHIC OBSERVATIONS OF COMET II, 1900 (BORRELLY–BROOKS).

BY H. K. PALMER.

This comet was discovered by BORRELLY, at Marseilles, and independently by BROOKS, at Geneva, N. Y., on July 23, 1900. At the time of its discovery it had a bright stellar nucleus of about the 6½ magnitude. It was first observed at the Lick Observatory on July 24th, and was found to be bright enough to warrant a series of photographs. Accordingly, on the 25th, this series was begun, and was continued until August 4th, when the Moon interfered. By the time the Moon was out of the way the comet had become so faint that further photographic observations were impossible.

On July 25th, the comet was photographed with the Crocker telescope, but on all succeeding nights, except August 4th, with a Willard lens attached to the five-inch Floyd telescope. The latter was used as a guiding telescope. Both the Crocker and the Willard lenses have apertures of six inches. The focal length of the Crocker is 30.82 inches, while that of the Willard lens is only 25.99 inches. On the photograph taken with the Crocker telescope, 1 degree = 0.538 inch; and on those taken with the Willard lens, 1 degree = 0.454 inch. The photographs

July 25. Exp. 1^h 10^m.

July 27. Exp. 2^h 15^m.

July 29. Exp. 2^h 29^m.

July 31. Exp. 2^h 6^m.

Aug. 2. Exp. 3^h 2^m.

Aug. 3. Exp. 3^h 9^m.

COMET 1900 II. (BORRELLY-BROOKS).

shown here have all been enlarged to the uniform scale of 1 degree = 0.75 inch.

The usual method of guiding these telescopes is to keep the head of the comet on the intersection of two coarse, dark cross-wires in the focus of the guiding telescope. The nucleus of this comet was so small that it was completely hidden by the wires, leaving nothing but the diffuse head to guide upon. After three nights' trial of this method, double wires were substituted for the single wires, and the nucleus was kept inside the square formed by their intersections. This kept the nucleus in sight all the time. The square was very little larger than the nucleus. This method required more careful watching than the other, as there were four intersections for the nucleus to hide behind instead of one; and when it disappeared some time was required to find it. So long as the nucleus was kept in sight within the square, this method gave better results than the other, as can be seen by comparing the star-trails on the photographs taken on July 25th and 27th with those taken later.

On July 25th, with an exposure of only 1^h 10^m, the tail could be traced for about four degrees. It was very slender and straight, but so faint that less than half of it can be seen on the accompanying photograph. With an exposure of six minutes on the same night, the tail appeared to be only half a degree long. On the plate of July 26th the tail was but forty minutes long, and was very faint, except within fifteen minutes of the head. The long, slender parts seen on the night before had disappeared, although the exposure was of 1^h 37^m duration. On the same night Mr. CRAWFORD secured a photograph with the Crocker telescope with an exposure of about two hours, which showed the same short tail. That night the tail seemed to fork about twenty minutes from the head. The same phenomenon was noticed on July 27th, whereas the plates taken after that showed the tail to be fan-shaped, as though the space between the forks had been filled in. On July 29th and August 3d the tail was fan-shaped for only half its length, the outer half being straight and slender. In both cases this extension was very faint — too faint to show on any of the accompanying reproductions. The length of the tail varied irregularly, not being entirely dependent upon the length of the exposure, as is shown in the following table. In this the first column gives the date of the exposure, the second the length of the exposure, and the third the length of the tail.

PHOTOGRAPHS OF COMET II, 1900, (BORRELLY–BROOKS).

Date.	Exposure.	Length of Tail	Position-Angle. Tail.	Position-Angle. Radius-Vector.	T—R.
July 25	$1^h\ 10^m$	4°	245°	253°	— 8°
25	6	30′	...	...	...
26	1 37	40	236	254	— 18
..	....	..	246	254	— 8
27	2 15	70	240	254	— 14
28	2 38	80	245	255	— 10
29	2 29	80	238	255	— 17
30	2 47	60	242	256	— 14
31	2 6	90	247	257	— 10
Aug. 1	3 10	60	244	257	— 13
2	3 2	40	250	258	— 8
3	3 9	120	250	258	— 8
4	57	30	...	...	...

The tail was so faint that if the air happened to be at all hazy the end of it would be obscured. This would hardly be sufficient to explain the difference between the lengths of the tail on August 2d and 3d.

On all the plates, except the second and last, the slide of the plate-holder was left out about two inches after the exposure, and the clock stopped, allowing the stars to trail on one end of the plate. The position-angle of the tail was then determined from the angle between these trails and the axis of the tail. The tail, in most cases, was so very short and ill-defined that the axis could not be determined with certainty, and consequently the position-angle was estimated to the nearest degree only. This quantity is given in column four of the table. Column five contains the computed position-angle of the radius-vector of the comet, and column six the difference between columns four and five, in the sense column four minus column five. Two values are given for the position-angle of the tail on July 26th, one for each fork. The mean of the two values of T—R is 13°,—but little greater than the mean of the whole column, which is 11°.6. While these values of T—R appear to vary a great deal, it is not much more than it is to be expected, as an examination of the accompanying photographs will show how uncertain the position of the axis of the tail is. Greater extent of tail can be seen on the negatives, but it is so faint that the extension hardly adds to the accuracy. The values of T — R have a range of only ten degrees, and all show a decided negative value, larger than the probable error of the result; showing that the tail did not coincide with the radius-vector of the comet.

The whole head was so bright that even on the six-minute plate the nucleus has disappeared from over-exposure. An exposure of less than a minute would probably have been sufficient to show the nucleus alone.

A PRELIMINARY DETERMINATION OF THE MOTION OF THE SOLAR SYSTEM.*

By W. W. Campbell.

The first investigation undertaken with the Mills spectrograph, in May, 1895, related to the determination of the radial velocities in the system of *Saturn*.† It confirmed, in all respects, the noted results announced by Professor Keeler a few weeks earlier. Determinations of stellar velocities were now undertaken, and results of considerable accuracy were at once obtained. The observed velocities of a bright solar type star could be depended upon to fall within a range of five or six kilometers. However, it soon became apparent that the instrument contained many defects. Some of these, with their remedies, have been described in my article on "The Mills Spectrograph," in the *Journal* for October, 1898; but the large majority were purely local, and do not call for special comment. The greater part of the first year was devoted to isolating and eliminating these defects; and it was not until the summer of 1896 that results considered satisfactory for publication were secured. Added precautions taken, and improvements made in the instrument and methods, have shown corresponding and gratifying increase of accuracy from year to year.

Following the methods of observation already described in the *Journal*, two thousand spectrograms have been secured since the summer of 1896. These include: plates of the solar spectrum for determining the camera-focus and scale-values; plates of stellar spectra for determining the focus of the 36-inch objective

* Reprinted from the *Astrophysical Journal* for January, 1901.

† *Astrophysical Journal*, August, 1895, pp. 127–135.

at different temperatures; plates of comparison-spectra, etc.; perhaps one hundred stellar spectrograms rejected for cause, without measurement; and in the neighborhood of fifteen hundred satisfactory spectrograms of about three hundred and twenty-five stars, situated between the North Pole and Declination — 30°. At least three or four hundred of these photographs relate to spectroscopic binaries, for some of which, such as *ζ Geminorum*, nearly fifty plates were needed.

It is not practicable to publish the observed velocities at the present time, for two reasons:—

(*a*) Many of the plates have been only partially measured, and reduced by approximate methods. Experience shows that these approximate results may be changed as much as $1\frac{1}{2}^{km}$ by the final measures and reductions, though the average change is much less.

(*b*) The reductions have not been based upon the definitive wave-lengths of the solar and comparison lines. These are not yet available, but they are expected soon.

Repeated requests have been made that the observations already secured should be used to determine the motion of the solar system with reference to the system of observed stars; and it is the purpose of this article to communicate the preliminary results of such an investigation.

Omitting several Type I stars whose lines could not be accurately measured, and some thirty spectroscopic and visual * binaries for whose centers of gravity the velocities are not yet known, there remain 280 stars available for determining the relative motion of our system. Inasmuch as this number is constantly increasing with the progress of the observations, and in a few years will, I hope, be doubled, and include stars distributed over the entire sky, it did not seem necessary to form an equation of condition for each star. The 280 stars were divided into 80 groups, by combining neighboring stars into one group; taking the mean of their individual velocities as the velocity of the group. The data for each of the 80 groups are contained in the first four columns of Table I.

Let r be the observed speed of a star with reference to the solar system; V the Sun's speed with reference to the system of 280 observed stars; and D the angular distance of a star from

* Such as *Sirius*, *Procyon*, etc.

the apex of the solar motion. Then each star, or each group of stars, furnishes an equation of condition having the form:—

$$V \cos D - v = 0. \qquad (1)$$

Let α_0, δ_0 be the coordinates of the apex, and α, δ those of the star; then we have $\cos D$ defined by the well-known equation for the distance between two stars or points,

TABLE I.

No. of Stars.	Mean R. A.	Mean Dec.	Mean Observed Velocity.	No. of Stars.	Mean R. A.	Mean Dec.	Mean Observed Velocity.
	h m	°	k		h m	°	k
2	0 26.5	−14.0	+17.0	3	12 20.4	+43.0	− 4.7
6	0 40.0	+57.8	−10.3	3	12 35.7	−22.5	− 1.7
5	0 45.0	+28.2	−24.2	3	12 48.1	+ 4.9	−17.0
3	1 23.0	−10.1	+12.7	2	13 6.2	+23.2	− 8.2
4	1 35.5	+43.9	+ 0.2	2	14 9.2	− 7.6	+ 3.0
3	1 43.7	+10.6	+ 7.3	5	14 14.9	+18.1	− 3.9
2	1 47.4	−19.0	+ 2.5	2	14 29.5	−25.6	+11.8
2	2 2.6	+24.2	−19.0	7	14 58.0	+29.6	−13.1
9	2 38.5	−14.1	− 3.2	4	15 2.4	+46.0	−28.5
3	2 54.4	+ 0.1	+21.7	4	15 23.2	+ 4.8	− 7.0
5	2 55.4	+50.2	+13.6	4	15 27.4	+65.8	−14.2
4	3 3.8	+41.2	+ 4.5	4	15 41.4	−12.9	− 1.0
3	3 16.9	+13.6	+ 6.7	4	16 17.1	−20.8	−11.1
3	3 45.8	− 9.2	−10.7	4	16 32.8	− 8.5	− 7.0
3	4 3.2	−17.3	+34.8	3	16 38.0	+13.3	−26.0
5	4 16.6	+18.0	+35.5	3	16 49.5	+35.9	−29.0
2	4 29.7	+79.8	− 3.0	3	17 44.7	+53.6	−22.3
4	4 46.8	+44.7	+ 8.2	4	17 53.6	+29.5	− 9.9
3	5 15.7	+37.4	+30.7	3	17 53.8	+ 5.3	− 7.5
2	5 17.0	+ 7.1	+22.0	6	18 18.6	− 7.2	− 5.4
4	5 23.5	−20.9	+ 1.8	6	18 36.4	−23.5	−23.5
3	5 32.6	− 7.5	− 0.7	3	18 38.6	+19.0	−28.5
3	5 51.5	+57.7	+ 5.0	2	18 43.0	+41.2	−20.5
4	6 18.1	+25.0	+24.8	6	18 48.9	+69.6	+ 6.4
2	6 41.0	−15.6	+50.5	4	19 42.1	+ 6.2	−19.9
3	6 43.3	+16.7	+ 6.3	5	19 42.6	+23.6	−11.6
3	7 32.4	+27.0	+11.3	4	20 3.6	+55.4	−44.2
2	7 33.8	−25.1	+42.0	3	20 19.3	− 9.1	− 8.7
2	7 47.0	+ 9.3	+34.0	3	20 48.9	+43.3	+ 1.0
2	7 50.6	− 6.0	+21.0	5	20 58.5	+12.8	−28.2
4	8 56.6	+10.5	+26.9	5	21 1.3	+31.9	− 2.6
2	8 57.8	+32.0	+25.2	4	21 24.6	−15.8	− 2.9
4	8 58.0	+65.7	− 4.0	3	22 00.2	+12.7	− 7.3
2	9 10.2	+47.2	+19.0	2	22 13.6	+54.7	−14.2
3	9 27.2	− 3.7	+12.3	4	22 32.6	− 6.7	−11.3
2	9 57.2	+22.3	−15.2	5	22 52.9	+25.4	− 0.2
5	10 40.2	−15.2	+19.6	2	23 10.6	+71.4	−26.5
5	10 44.7	+38.1	− 2.8	4	23 10.7	−18.7	+ 5.6
2	11 11.6	+66.1	± 0.0	2	23 16.0	+43.8	− 2.0
6	11 32.8	+ 6.2	+ 3.7	4	23 31.0	+ 5.0	− 0.9

$$\cos D = \sin \delta_0 \sin \delta + \cos \delta_0 \cos \delta \cos (\alpha_0 - \alpha). \qquad (2)$$

If we place

$$\left.\begin{aligned} x &= V \sin \delta_0 \\ y &= V \cos \alpha_0 \cos \delta_0 \\ z &= V \sin \alpha_0 \cos \delta_0 \end{aligned}\right\} \quad (3)$$

equations (1) take the form

$$\sin \delta \,.\, x + \cos \alpha \cos \delta \,.\, y + \sin \alpha \cos \delta \,.\, z - v = 0 \quad (4)$$

from which the values of x, y, and z may be determined; and the values of V, α_0, and δ_0 may then be found from (3) by the relations

$$\left.\begin{aligned} V^2 &= x^2 + y^2 + z^2 \\ \tan \alpha_0 &= \frac{z}{y} \\ \sin \delta_0 &= \frac{x}{V} \end{aligned}\right\} \quad (5)$$

The values of α and δ for each group were substituted in equation (4), and the resulting equation was weighted in proportion to the number of stars on which it is based, as indicated in column one of the table. The eighty equations thus formed were combined and solved by the method of least squares, and the following elements of the solar motion were obtained:—

$$\begin{aligned} V &= - \;19.89^{km} \pm 1.52^{km} \\ \alpha_0 &= \;277^\circ\, 30' \;\pm 4^\circ.8 \\ \delta_0 &= - \;19^\circ\, 58' \;\pm 5^\circ.9 \end{aligned}$$

The list of stars employed in this investigation includes all that were available; none were rejected arbitrarily, on account of very high speed or otherwise. The results represent the solar motion relative to the entire system of observed stars. Had a dozen stars of great velocity been rejected, the speed and direction of the motion would have been only slightly different, but the computed probable errors would have been very much smaller than those appended.

On the basis of these elements the component correction for the solar motion was computed and applied to each star. The 280 results obtained in this manner represent the individual stellar components of motion in the line of sight, with reference to the entire system. Of these there are

	Km per second.
152 positive, average,	+17.01
128 negative, average,	−17.10
280 numerical average,	17.05

The average component velocity of each star in a plane at right angles to the line of sight is therefore

$$\frac{\pi}{2} \cdot 17.05 = 26.78^{km} \text{ per second;}$$

and the average velocity *in space* of each star in the system is

$$2 \times 17.05 = 34.10^{km} \text{ per second.}$$

The Sun's relative velocity, 19.9^{km}, is therefore much smaller than that of the average star of the system, 34.1^{km}.

The 280 stars were classified roughly, according to their spectral types, in the following manner: the *Harvard Photometry* contains estimates of their brightness, based upon the visual radiations. The *Draper Catalogue* estimates their brightness by virtue of the photographic intensities of their spectra in the $H\gamma$ region. The difference between the visual and photographic magnitudes is very small in the case of the white stars, such as *β Orionis;* it is usually from 1.5 to 2.0 magnitudes for the solar type stars, such as *β* and *γ Andromedæ;* and is fully 2.5 magnitudes for red stars, such as *α Scorpii.*

In the system of stars observed, the difference of magnitude is equal to or greater than 1.0 for 144 stars. Subdividing these according as their component velocities in the line of sight are positive or negative, we have

78	positive, average component,	$+17.07^{km}$
66	negative, average component,	-14.99
144	numerical average, ...	16.12

For 136 stars the difference of magnitude is less than 1.0, as follows:—

73	positive, average component,	$+16.94^{km}$
63	negative, average component,	-19.32
136	numerical average, ...	18.04

The discrepancy of 1.9^{km} in the results is hardly sufficient to justify any statement as to the effect of spectral type upon velocity.

The relations between visual brightness and velocity was next investigated.

Of stars equal to or brighter than 3.0 magnitude, there are

26	positive, average component,	$+13.11^{km}$
21	negative, average component,	-12.99
47	numerical average, ...	13.05
	Corresponding velocity in space,	26.10

Of stars lying between magnitudes 3.1 and 4.0 inclusive, there are

59 positive, average component,	$+ 17.70^{km}$
53 negative, average component,	$- 14.42$
112 numerical average, ...	16.15
Corresponding velocity in space, .	32.30

Of stars fainter than 4.0 magnitude, there are

66 positive, average component,	$+ 17.93^{km}$
55 negative, average component,	$- 21.27$
121 numerical average, ...	19.44
Corresponding velocity in space, .	38.88

The progression in these results is so pronounced, and the differences are so large, that I think we are justified in drawing the important conclusion that the faint stars of the system are moving more rapidly than the bright stars. This apparent fact, derived quite independently of any assumption as to the relative distances of the stars of different magnitudes, should profoundly affect the question of and the methods of determining the structure of our sidereal system. If the fainter stars are moving relatively more rapidly than has been previously assumed, they must be relatively farther from us than the investigations of their proper motions have led us to conclude.

This progression is in no wise due to an increase of probable error of a velocity determination with decreasing magnitude. The probable error of a single determination is well under half a kilometer for such excellent stars as *Polaris* and *Procyon;* and it is not much greater for fifth-magnitude stars whose spectra contain well-defined lines.

The elements of the solar motion deduced above depend upon the assumption that their most probable values are those which make the sum of the squares of the residual stellar components of speed in the line of sight a minimum. This, in turn, assumes that the magnitudes of these components are distributed according to the law of accidental errors. No doubt they are distributed according to a somewhat different law, which I hope to investigate fully a few years later, before making a definitive determination of the motion, based upon a much larger number of stars distributed over the entire sphere.*

* An additional reason for delay arises from the fact that many years of observation are required to establish constancy of stellar velocities, in some cases; of the stars used in the above determination, two have since been discovered to have variable velocities.

The Right Ascension of the apex, 277° 30′, agrees exactly with the value deduced by Professor NEWCOMB * from all the "proper motion" data available; and differs only 1° 30′ from Professor KAPTEYN'S † assumed value, 276°. My value of the Declination + 19° 58′, differs widely from NEWCOMB'S value, + 35°, and KAPTEYN'S, + 34°. It must be noticed that very few radial velocities are available for the region — 15° to — 30°, and none whatever south of — 30° Declination. Fully one third of the sky is unrepresented in the solution. The data for determining the Declination of the apex are extremely unsymmetrical in arrangement. The data north of the line of motion are fairly complete, whereas the data to the south are very incomplete. To determine the Declination therefrom is somewhat similar to flying with one wing very imperfect. The Right Ascension, on the contrary, is determined from data reasonably symmetrical in distribution.

A comparison of my results with those obtained by STUMPE ‡ from proper motions is of great interest. He classified the stars of relatively large proper motions according to their visual magnitudes, with the following results for the position of the apex:

No. of Stars.	Magnitude.	R. A.	Dec.
284 . . .	1 to 5.5	263°.8	+ 31°.1
473 . . .	5.6 to 7.5	290. 7	+ 37. 5
238 . . .	7.6 to >	286. 7	+ 46. 9

In view of these widely different positions of the apex, it is perhaps not surprising that my result for Declination, depending upon even brighter stars than his first group should be smaller than any hitherto obtained.

The motion of the solar system is a purely relative quantity. It refers to specified groups of stars. The results for various groups may differ widely, and all be correct. It would be easy to select a group of stars with reference to which the solar motion would be reversed 180° from the values assigned above. It is perhaps unsafe to draw conclusions, from my value of the Declination, concerning the drift of the brighter (and presumably nearer) stars until the data from the southern sky are available.

Before making the preceding solution for the solar motion by the method of least squares, I had already made an approxi-

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* *Astronomical Journal*, No. 457, pp. 4, 5.

† *Astronomische Nachrichten*, No. 3487, p. 104.

‡ *Astronomical Journal*, No, 457, p. 5.

mate determination of the speed of the solar system, by a different method, as follows: the apical distance D of each star was computed from NEWCOMB'S assumed coordinates of that point ($\alpha = 277°.5$; $\delta = +35°$). The stars were formed into groups according to their apical distances, as indicated in the first column of Table II. The number of stars in each group is given in column two. The mean apical distance of the group is $[D]$ and the mean observed velocity is $[v]$. It is interesting to note that each $[v]$ between apical distances 0° and 90° is negative, and each one between 90° and 180° is positive. Each radial velocity furnishes an equation of condition of the form

$$V - v \sec D = 0. \tag{6}$$

from which to determine V. We shall assume that the weight of each determination is equal to $\cos D$. The resulting value of V will now be given by

$$V = \frac{\Sigma (n \cos [D] [v] \sec [D])}{\Sigma n \cos [D]} = \frac{\Sigma n [v]}{\Sigma n \cos [D]}. \tag{7}$$

Substituting the values of n, $[v]$, and $[D]$ in this equation, I obtained

$$V = -20.4^{km}.$$

TABLE II.

Apical distances.	n	$[D]$	$[v]$	$\cos [D]$
0°— 10°	4	7.4	— 9.9	+0.992
10 — 20	10	15.5	—24.0	+ .964
20 — 30	16	21.7	—17.5	+ .906
30 — 40	24	34.8	—12.9	+ .821
40 — 50	24	44.1	—1[illegible].6	+ .718
50 — 60	29	54.6	— 6.1	+ .579
60 — 70	29	64.4	— 7.0	+ .432
70 — 90	47	79.7	— 2.7	+ .179
90 —110	35	99.4	— 8.0	— .163
110 —120	19	110.3	—14.4	— .443
120 —130	18	121.4	—13.8	— .566
130 —140	10	134.4	—16.4	— .700
140 —150	5	145.1	—14.6	— .820
150 —160	6	156.0	—29.3	— .914
160 —170	4	164.0	— 9.[illegible]	—0.961
	280			

$$V = \frac{\Sigma n [v]}{\Sigma n \cos [D]} = \frac{-3010}{147.5} = -20.4^{km}.$$

If we use this value of V as a basis for further approximations to its true value, by the method of KAPTEYN,* we shall obtain $V = -19$ kilometers; though it should be said that this method involves assumptions concerning proper motions.

The foregoing data bear decisively upon the question of stellar parallaxes and other fundamental problems; but these portions of the subject are reserved for a future paper.

The work with the Mills spectrograph has furnished many important by-products. Special mention may be made of the discovery of an unexpectedly great number of spectroscopic binaries. Two or more satisfactory observations have been secured for each of 285 stars of my programme. From the Mills spectrograph observations alone we have discovered that thirty-one† of these stars are spectroscopic binaries. To these we must add three binaries in the same list previously discovered by another observer,‡ making thirty-four in all. That is, of 285 observed stars, *more than one star in nine is a spectroscopic binary.* Further, five additional suspected binaries await verification, and it is altogether probable that many other stars in the list are binaries awaiting discovery. Two plates are not sufficient to detect variable velocity, even in many cases of short period; and still less are they sufficient in many cases of long period, now coming to light by virtue of our older observations. It is not improbable that at least one star in five or six will be found to be a spectroscopic binary; and I should not be surprised to see a still larger ratio established.

The proven existence of so large a number of stellar systems differing widely in structure from the solar system gives rise to a suspicion, at least, that our system is not of the prevailing type of stellar systems. The new field of astronomical research thus opened up is of great richness, and may well occupy the attention, for an indefinite period, of the large number of observers and institutions now engaging in its development. It is perhaps unnecessary to say that the measure of success attainable is

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* *Astronomische Nachrichten*, No. 3487.

† Twenty-five of these have been announced in the *Journal*, and six now await announcement.

‡ Dr. BÉLOPOLSKY, at Pulkowa, α_1 *Geminorum*; the well-known variable stars δ *Cephei* and η *Aquilæ*; and the independent and prior discovery of the binary character of the well-known variable, ζ *Geminorum*.

dependent upon the degree of accuracy * realized in the observed velocities.

It is a pleasure to record that I have been assisted most efficiently in these investigations, since August, 1897, by Mr. W. H. WRIGHT, assistant astronomer.

LICK OBSERVATORY,
UNIVERSITY OF CALIFORNIA, December, 1900.

PLANETARY PHENOMENA FOR MAY AND JUNE, 1901.

BY MALCOLM MCNEILL.

MAY.

There will be a very close approximation to a lunar eclipse at Full Moon on May 3d, the Moon passing within 1′ of the Earth's shadow. At the succeeding New Moon, May 17th, there will be a total eclipse of the Sun. The line of totality lies in the southern hemisphere, and passes almost wholly through the ocean, but crosses the islands of Sumatra, Borneo, and New Guinea. The eclipse is remarkable on account of the great duration of totality, nearly six and one half minutes in some places, a duration four times as great as any available duration for the eclipse of May 28, 1900.

Mercury is a morning star at the beginning of the month, but passes superior conjunction on May 14th, and becomes an evening star. It moves rapidly away from the Sun, eastward and northward. Toward the end of the month it becomes a comparatively easy object in the evening twilight, not setting until an hour and a half after sunset.

Venus is now an evening star, having passed superior conjunction with the Sun on April 30th, but remains quite close to the Sun throughout the month. At the end of the month it sets only a little more than half an hour after sunset, and will be very hard to see.

Mars is still waning, increasing its distance from us 24,000,000 of miles during the month, and diminishing in brightness about

* In the later observations of the *best stars* with the Mills spectrograph, an extreme range of two kilometers would afford strong suspicion of variable velocity; and the greater portion of a smaller range due to unavoidable errors would arise not from errors in the spectrograms, I believe, but from changes in the observer's personal habits of measuring the plates.

one half. It moves about 10° east and 5° south during the month through the constellation *Leo*. On May 4th it passes between *Regulus* and *η Leonis* in the handle of the Sickle, not quite 2° north of the first. On May 31st it occupies a position about 3° south of the position it held on February 12th.

Jupiter and *Saturn* are now coming nearer to being evening stars, both rising before 10 P.M. toward the close of the month. Both are still in the constellation *Sagittarius*, and both are retrograding, *Jupiter* a little faster, on account of its lesser distance from us. At the close of the month their distance apart is about 4°, half a degree greater than it was at the beginning of the month.

Uranus rises earlier by about two hours, and has nearly come to opposition. It is retrograding in the southern extension of *Ophiuchus*.

Neptune sets shortly after sunset, and is getting into poor position for observation.

JUNE.

The Sun reaches the solstice and summer begins on June 21st, 7 P.M., Pacific time.

June affords the best time of the present year for observations of *Mercury*. The planet is an evening star throughout the month, and until the very last days sets more than an hour and one half after sunset. It comes to greatest east elongation on June 15th. This elongation is nearly 25°, more than 6° greater than the preceding greatest east elongation in February.

Mercury is in conjunction with *Venus*, about 4° south, on the evening of June 30th.

Venus is an evening star, rather farther from the Sun than it was in May. After the middle of the month it sets more than an hour after sunset, and will be an easy object to see.

Mars is to be found farther to the west in the evenings, and sets shortly after 11 P.M. by the end of the month. It still keeps up its rapid recession from the Earth, losing more than 20,000,000 miles and more than one third in brightness during the month. It is in the constellation *Leo*, and moves 13° east and 6° south, nearly to *Virgo*. On June 12th it reaches the point at which it began its retrograde motion in January, except that it is now about 3° south of its former position.

Jupiter and *Saturn* are still near together, although separating slightly. By the end of the month they rise about midnight.

They are still in *Sagittarius*, both moving eastward, *Jupiter* 4° and *Saturn* 2°, during the month, and at the end of the month *Jupiter* is about 6° west of *Saturn*. After their retrograde motion ceases, *Jupiter* will again approach *Saturn*, and they will come into conjunction with each other late in November. *Jupiter* is in opposition with the Sun, and consequently above the horizon during the entire time the Sun is below, on June 30th. The opposition of *Saturn* comes five days later.

Uranus is in opposition on June 5th. It retrogrades a little more than 1° in *Ophiuchus*, and at the close of the month is about 30′ north of the sixth-magnitude star *24 Ophiuchi*.

Neptune is in conjunction with the Sun on June 20th, and changes from evening to morning star.

MAY–JUNE, 1901.

PHASES OF THE MOON, P. S. T.

Full Moon . . .	May 3,	10ʰ 19ᵐ	A. M.
Last Quarter . . .	May 11,	6 38	
New Moon . . .	May 17,	9 38	P. M.
First Quarter . . .	May 24,	9 40	
Full Moon . . .	June 2,	1 53	A. M.
Last Quarter . . .	June 9,	2 0	P. M.
New Moon . . .	June 16,	5 33	A. M.
First Quarter . . .	June 23,	12 59	P. M.

THE SUN.

1901.	R. A.	Declination.	Rises.	Transits.	Sets.
May 1,	2ʰ 32ᵐ	+ 14° 57′	5ʰ 5ᵐ A.M.	11ʰ 57ᵐ A.M.	6ʰ 49ᵐ P.M.
11,	3 11	+ 17 46	4 54	11 56	6 58
21,	3 50	+ 20 6	4 45	11 56	7 7
31,	4 31	+ 21 51	4 39	11 58	7 17
June 10,	5 12	+ 22 59	4 36	11 59	7 22
20,	5 53	+ 23 26	4 36	12 1 P.M.	7 26
30,	6 35	+ 23 13	4 39	12 3	7 27

MERCURY.

May 1,	1 39	+ 8 18	4 36 A.M.	11 4 A.M.	5 32 P.M.
11,	2 55	+ 16 19	4 44	11 41	6 38
21,	4 24	+ 22 54	5 7	12 30 P.M.	7 53
31,	5 49	+ 25 34	5 41	1 16	8 51
June 10,	6 55	+ 24 35	6 13	1 43	9 13
20,	7 37	+ 21 41	6 27	1 45	9 3
30,	7 50	+ 18 40	6 17	1 18	8 19

VENUS.

1901.	R. A.	Declination.	Rises.	Transits.	Sets.
May 1,	2 33	+14 12	5 10 A.M.	11 59 A. M.	6 48 P. M.
11,	3 22	+18 3	5 5	12 8 P. M.	7 11
21,	4 13	+21 6	5 4	12 19	7 34
31,	5 5	+23 11	5 8	12 32	7 56
June 10,	5 59	+24 9	5 18	12 46	8 14
20,	6 52	+23 57	5 32	1 0	8 28
30,	7 45	+22 34	5 53	1 14	8 35

MARS.

May 1,	10 0	+14 28	12 34 P.M.	7 24 P.M.	2 14 A.M.
11,	10 11	+13 7	12 11	6 56	1 41
21,	10 25	+11 32	11 50 A.M.	6 30	1 10
31,	10 40	+ 9 45	11 33	6 6	12 39
June 10,	10 57	+ 7 48	11 18	5 44	12 10
20,	11 15	+ 5 42	11 4	5 23	11 42 P.M.
30,	11 34	+ 3 28	10 51	5 2	11 13

JUPITER.

May 1,	18 57	—22 39	11 44 P.M.	4 23 A.M.	9 2 A.M.
June 1,	18 50	—22 51	9 37	2 15	6 53
July 1,	18 35	—23 10	7 26	12 2	4 38

SATURN.

May 1,	19 11	—21 55	11 56 P.M.	4 37 A.M.	9 18 A.M.
June 1,	19 7	—22 3	9 50	2 31	7 12
July 1,	18 58	—22 18	7 45	12 25	5 5

URANUS.

May 1,	17 0	—22 45	9 48 P.M.	2 26 A.M.	7 4 A.M.
June 1,	16 55	—22 38	7 42	12 20	4 58
July 1,	16 50	—22 30	5 35	10 14 P.M.	2 53

NEPTUNE.

May 1,	5 48	+22 15	7 53 A.M.	3 13 P.M.	10 33 P.M.
June 1,	5 53	+22 17	5 55	1 15	8 35
July 1,	5 57	+22 18	3 52	11 22 A.M.	6 42

Eclipses of Jupiter's Satellites, P. S. T.

(Off left-hand limb as seen in an inverting telescope.)

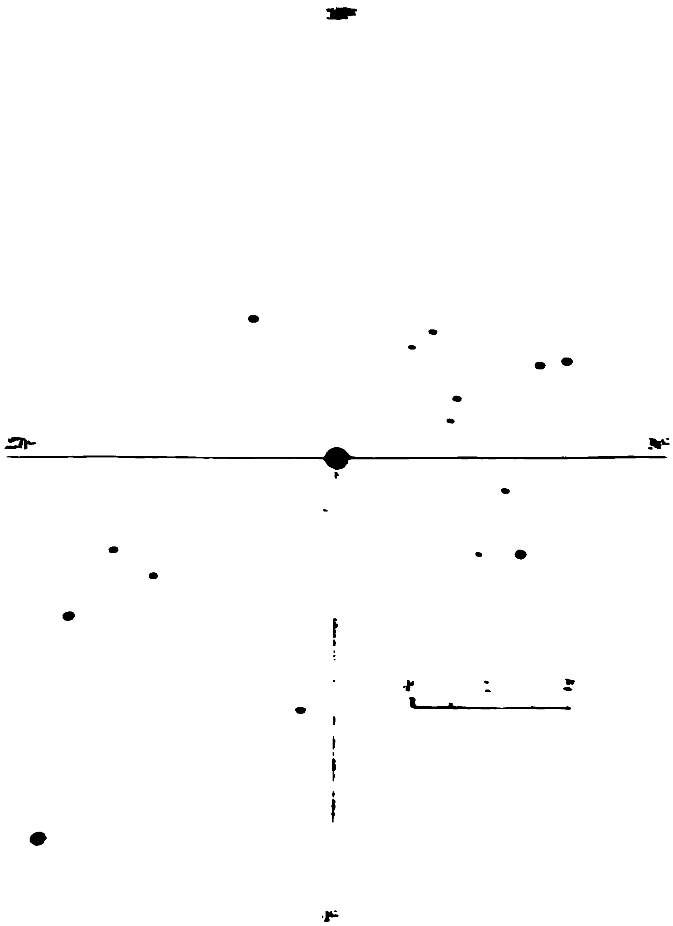
I, D, May	4,	1^h	46^m	A.M.	I, D, June	3,	3^h	50^m	A.M.
II, D,	6,	9	54	P.M.	I, D,	4,	10	19	P.M.
III, D,	10,	9	51		II, D,	7,	9	27	
III, R,	11,	12	37	A.M.	I, D,	12,	12	13	A.M.
I, D,	11,	3	40		I, D,	13,	6	41	P.M.
I, D,	12,	10	9	P.M.	II, D,	15,	12	2	A.M.
II, D,	14,	12	28	A.M.	I, D,	19,	2	7	
III, D,	18,	1	49		I, D,	20,	8	36	P.M.
III, R,	18,	4	36		II, D,	22,	2	37	A.M.
I, D,	20,	12	2		III, D,	22,	9	42	P.M.
II, D,	21,	3	2		I, D,	26,	4	1	A.M.
I, D,	27,	1	56		I, D,	27,	10	30	P.M.
I, D,	28,	8	25	P.M.	III, R,	30,	4	35	A.M.
II, D,	31,	6	53						

(FORTIETH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to M. Michel Giacobini, of the Nice Observatory, for his discovery of an unexpected comet on December 20, 1900.

The Committee on the Comet-Medal,

W. W. Campbell,
W. M. Pierson,
Chas. Burckhalter.



[illegible] AND THE FAINT STARS NEAR IT.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

NOVA PERSEI.

The discovery of a new star in the constellation *Perseus*, by Dr. T. D. ANDERSON, a private astronomer of Edinburgh, on the morning of February 22d, is one of the most interesting astronomical events of recent times. The discovery was announced by Professor COPELAND, Astronomer Royal for Scotland, with the following statement:—

"The great new star was discovered by Dr. T. D. ANDERSON, of this city, at 2:40 A.M. on Friday, 22d inst. At that time it was of the 2.7 magnitude, or fully half a magnitude fainter than the Pole Star, and shone with a bluish white light. Dr. ANDERSON himself kindly brought the news of this important discovery to the observatory in the forenoon, and marked off the exact position of the *Nova* on the map in ARGELANDER's great atlas of the northern heavens. Dr. ANDERSON's reputation as the discoverer of *Nova Aurigæ* in 1892, and of more than a score of telescopic variable stars, placed the reality of this new discovery beyond all doubt; so telegrams were at once dispatched to Greenwich and to Kiel for distribution to the observatories of the world.

"Evening had scarcely closed in when the *Nova* could be seen with the naked eye, even through light drifting clouds. To my eye it appeared to be of the first magnitude, being slightly brighter than *Aldebaran*. On examining its spectrum, we were astonished to find it almost absolutely continuous, and it was only after some time that Dr. HALM detected a number of delicate dark (Fraunhofer) lines, which I was able to confirm. Unfortunately, the sky clouded over before further critical observations could be made. Mr. HEATH was so fortunate as to secure a photograph of the new star at a time when all the neighboring stars were obscured by thick haze. The night of the 23d was very cloudy, and spectroscopic observations were impossible; but when, through a break in the clouds about 8 P.M., Dr. HALM and Mr. CLARK saw the star, they clearly made it out to be brighter than *Capella*, in fact to be the brightest star north of the celestial equator.

"A new special feature of this, the most considerable new star of modern times, is its enormous increase in brightness since its discovery,

* Lick Astronomical Department of the University of California.

while all other new stars seem to have been discovered when at their greatest brilliancy, from which they rapidly declined.

"Dr. ANDERSON's place of the *Nova* for 1901 is: Right Ascension, $3^h\ 24^m\ 25^s$; North Declination, 43° 34′, or a little following the center of the line joining the stars *Beta* and *Delta*, in the constellation of *Perseus*."

It may be said that the resources of nearly all the active observatories were at once devoted to the study of the wonderful stranger, in so far as they promised to yield useful results.

A fact of great interest was promptly announced by Professor E. C. PICKERING, Director of Harvard College Observatory. Photographs of this region of the sky had been secured, in the course of their regular surveys, on February 2d, 6th, 8th, 18th, and 19th, none of which recorded a star in the position of the *Nova*, though the last plate contained images of 11th-magnitude stars. The *Nova* thus increased from fainter than 11th magnitude to the 2.7 magnitude in less than three days; and on the 24th had become the brightest star in the northern hemisphere.

The first opportunity for securing observations at Mt. Hamilton occurred on the forenoon of February 24th. There was no difficulty in finding it with the 12-inch telescope, in broad daylight. Comparison of the brightness of the *Nova* with that of *Capella* showed that the former was half a magnitude the brighter.

The position of *Nova Persei* was determined from meridian-circle observations by Professor TUCKER on eight consecutive nights, from February 24th to March 3d, to be

$$\text{Right Ascension} = 3^h\ 24^m\ 28^s.086$$
$$\text{Declination} = 43^\circ\ 33'\ 54''.03$$

referred to the mean equinox of 1901.0. Readers will have no difficulty in locating the *Nova*, by means of these coordinates, in their star-charts.

The position of the *Nova* with reference to a number of neighboring faint stars has been accurately determined by Mr. AITKEN, using the micrometer of the 36-inch refractor.

Mr. PALMER has secured photographs of *Nova Persei* and the surrounding stars, and has measured its position with reference to four catalogue stars on the plates.

The brightness of the star has been estimated on every clear night by Messrs. TUCKER and AITKEN. It has diminished from zero magnitude, on February 24th, to the fourth magnitude and fainter, the latter part of March, in an irregular manner.

Our two single-prism spectrographs having just been shipped to Sumatra, the spectroscopic observations on February 24th were made with the Mills spectrograph. On the 25th and succeeding nights efficient one-prism instruments were available. Those fortunate enough to secure observations on the 22d and 23d reported that the spectrum was practically continuous, traversed by dark lines, on those dates. Observations secured here and elsewhere on the 24th and later showed that the spectrum was rapidly approaching the type of new-star spectrum exemplified by *Nova Aurigæ*, discovered by Dr. ANDERSON in 1892; and by *Nova Normæ* (1893), *Nova Carinæ* (1895), *Nova Sagittarii* (1898), and *Nova Aquilæ* (1899), discovered by Mrs. FLEMING on the Draper Memorial Photographs. Some minor points of difference exist; but the general features are the same, leaving no doubt that all these new stars exemplify the same class of phenomena.

The bright bands which were very prominent in *Nova Aurigæ* are present, with greater width, in *Nova Persei.* The stronger bands have, similarly, dark bands on their violet edges. The contrasts between bright and dark bands are weaker in the present star than in that of 1892.

It was noticed on the 25th of February that the D_1 and D_2 lines of sodium are present as narrow dark lines within the broad bright D band. A little later the fine dark H and K lines were found in the broad bright calcium bands. These were utilized at once for determining the velocity of *Nova Persei* in the line of sight. Observations from February 25th to March 18th yielded fairly consistent values of 6 kilometers per second recession from the solar system, depending upon the sodium and calcium lines.

A large number of beautiful spectrum plates have been secured, which Mr. WRIGHT is engaged in measuring and reducing preparatory to their publication in detail.

The cause of this star's sudden appearance is unknown. It undoubtedly existed previously as a dark and invisible star, or stars, in its present position. Some astronomers are inclined to hold to the view that we are dealing with two bodies traveling through space with an enormous relative velocity; but it seems to me that the substantial agreement of the features of the last half-dozen new-star spectra is practically conclusive evidence against this theory; and the work of WILSING shows that such an hypothesis is unnecessary. Likewise, the theory that the phenomena are caused by a dark body rushing violently through a nebulous cloud seems to be too special to fit a uniform class of phenomena. Whether a stupendous volcanic outburst from one star, whatever its cause, or the collision of two dark bodies, could supply the observed facts, remains in doubt. The spectrum contains sufficient proof that the atmosphere of the star is disturbed in the extreme. W. W. CAMPBELL.

March 31, 1901.

Nova Persei and the Faint Stars near It.

The following measures were made for the purpose of locating the faint stars that are visible in the telescope close to the new star discovered by ANDERSON. All the stars that could be seen with the 36-inch telescope within 3′ of the *Nova* were measured, as well as a few that are more distant. As all of these stars are quite faint, the new star was also connected with the 9.0-magnitude star (Bonn A. G. Catal., 2948), which is about 6′ north of and preceding it.

The observing conditions on all the nights available for these measures were not very favorable, and the measures of distance were nearly all difficult. This was especially the case with the nearest star (a), which was at the limit of vision. The estimates of magnitude must be considered as relative rather than absolute. In addition to the estimates made on the nights of the measures, the following comparative estimate was made on March 29th: $o = 12.5$; $k = i = f = 13.0$; $l = m = 13\frac{1}{4}$; $j = c = 13.5$; $g = h = n = 14.0$; $b = 14\frac{3}{4}$; $e = 15.5$; $d = 16.0$; a, not visible.

The diagram facing page 65 shows the relative positions of these stars.

Nova and *a*.

Date.	Angle.	Distance.	Magnitude.
1901.184	348°.0	39″.39	—16.5
.203	348 .7	40 .28	—16.5
1901.19	348°.4	39″.82	—16.5

b.

Date.	Angle.	Distance.	Magnitude.
1901.184	107°.9	90″.86	—14.5
.239	108 .1	91 .88	—14.5
1901.21	108°.0	91″.37	—14.5

c.

1901.159	117° 2	102″.31	—13.5
.184	116 .6	102 .30	—13.5
.239	116 .7	103 .33	—13.5
1901.19	116°.8	102″.65	—13.5

e.

1901.203	142°.7	121″.34	—15.5

f.

1901.159	211°.4	123″.96	—13.0
.184	210 .9	125 .13	—13 0
.239	210 .9	124 .76	—13.0
1901.19	211°.1	124″.62	—13.0

i.

1901.159	62°.8	158″ 33	—13.0
.184	63 .2	158 .21	—12.5
.203	63 .3	157 .95	—13.5
1901.18	63°.1	158″.16	—13.0

k.

1901.203	114°.6	168″.86	—13.0
.239	114 .5	170 .64	—13.5
1901.22	114°.5	169″.75	—13.2

n.

1901.184	352°.0	192″.75	—13.5
.239	352 .3	193 .39	14.0
1901.21	352°.2	193″.07	13.8

o.

1901.159	300°.3	236″.35	—13.0
.184	300 .4	236 .63	—12.0
1901.17	300°.4	236″.49	—12.5

p (= Bonn A. G. 2948).

1901.176	321°.6	367″.73	—9.0
.184	321 .7	367 .45	—9.0
1901.18	321°.6	367″.59	—9.0

e and *d.*

1901.203	306°.7	19″.50	—16.0

i and *g.*

1901.203	270°.4	30″.91	—13.5
.239	269 .6	31 .34	14.5
1901.22	270°.0	31″.12	—14.0

i and *k*.

1900.203	194°.5	45″.42	—13.5
.239	195 .4	45 .97	—14.0
1901.22	195°.0	45″.70	—13.8

o and *j*.

1901.159	114°.9	71″ 71	—13.0
.184	114 .7	72 .78	—14.0
.239	114 .5	71 .85	—13.5
1901.19	114°.7	72″.11	—13.5

o and *l*.

1901.159	144°.2	61″.39	—13.5
.184	144 .2	61 .68	—13 0
.239	144 .3	61 .99	—13.0
1901.19	144°.2	61″.69	—13.2

k and *m*.

1901.203	100°.4	21″.39	—13.5
.239	100 .2	22 .01	—13.0
1901.22	100° 3	21″.70	—13.2

R. G. AITKEN.

THE VELOCITY OF GROOMBRIDGE 1830 IN THE LINE OF SIGHT.

The star No. 1830 in GROOMBRIDGE'S catalogue has been called the "Runaway Star," on account of its large proper motion. Its position in the heavens is changing at the rate of 7″.05 per year,—a speed sufficient to carry it over one degree in five hundred years. This was the maximum stellar motion known up to the year 1898, at which date an 8th-magnitude star in the southern hemisphere was found to have a proper motion of 8″.7 per annum.

Several determinations of the parallax of Groombridge 1830 have been made. The separate results differ widely in value, but they are in substantial agreement in placing the star at a great distance: it is probable that at least twenty stars with large proper motions are nearer than Gr. 1830. From a consideration of the merits of the individual determinations, NEWCOMB has adopted 0″.14 as its most probable parallax. Assuming this to be its true value, the component of the star's velocity at right angles to the line of sight is 240 kilometers (150 miles) per second. This is by far the largest cross-motion assigned for any of the stars whose parallaxes have been measured.

Inasmuch as the proper motion, both in arc and in linear measure, takes account of the component of motion at right angles to the line of sight, it is of unusual interest to have a determination of the component of speed in the line of sight. This determination has been made with the Mills spectrograph, after replacing its three dense prisms by one light prism.

Four spectrum photographs have been secured in the past two months, of which two are very satisfactory, and one is excellent. The results given by the four are in substantial agreement; those given by the best two are — 93 and — 97 kilometers (58 and 60 miles approach) per second, respectively. Their mean value, -95^{km}, is possibly uncertain to the extent of five kilometers.

In view of the very great uncertainty existing in the value of the parallax, no interest attaches to the value of the angle resulting for the direction of the star's motion in space.

Gr. 1830 is of the 6.5 visual magnitude. The photographic magnitude on the Draper Catalogue standard, must be in the vicinity of 7.5, though this catalogue assigns it as 6.63. The spectrum is approximately of the solar type, though it may incline strongly toward the characteristics of *Procyon* or *α Persei*.

The best photograph was secured with an exposure of two hours, in average seeing, using slit-width $0^{mm}.032$. The measurable lines on the plate are between $\lambda\lambda$ 4000 - 4415. The region λ 4415 - $H\beta$ is over-exposed. The spectrum is about $0'.25$ in width. The light flint prism gives about two ninths as much dispersion as the three Mills prisms.

The greatest interest of the observations lies in the fact that fairly accurate determinations of stellar velocities are shown to be possible down to the eighth or ninth photographic magnitudes, provided their spectra contain well-defined lines.

W. W. CAMPBELL.

COMET NOTES.

Professor KREUTZ has computed elliptic elements for Comet *c* 1900 (GIACOBINI) which show that it is a member of the same group to which Comet Wolf and Comet Barnard belong. The periodic time is a little less than seven years. Long-continued cloudy weather during January and February made it impossible to follow this object as closely as was desirable. Observations were secured with the 12-inch on January 13th and 15th, and with the 36-inch on February 15th. The observed places are in good agreement with those computed from the elliptic elements.

On February 15th the comet was a very difficult object to measure, even with the great refractor, and on March 8th it could not be seen at all, though the conditions were good.

Comet Brorsen, which was expected to return to perihelion in January, was looked for with the 36-inch telescope on several mornings in February, but without success. The atmospheric conditions during the search were good, and a field about two degrees square was examined on each night.

R. G. Aitken.

Some Stars with Large Radial Velocities.

While pursuing the regular programme of observation with the Mills spectrograph, it was found that the following stars have large velocities in the line of sight as indicated below:—

ε *Andromedae* (α = 0h 33m; δ = + 28° 46').

1898, October 4	− 83.4 km	Wright.
October 5	− 83.3	Wright.
1899, August 23	− 84.[illegible]	Wright.
1900, August 22	− 83.4	Wright.
Mean,	− 83.[illegible]	

μ *Cassiopeiae* (α = 1h 2m; δ = − 54° 20').

1900, September 5	− 97.2 km	Wright.
September 18	− 97.0	Wright.
December 11	− 98.	Campbell.

The proper motion of μ *Cassiopeiae* is 3".75 per year. Jacoby's parallax, determined from the Rutherford photographs, is 0".275. These correspond to a motion at right angles to the line of sight of 65 km per second, though this includes nearly the full component of the motion of the solar system.

δ *Leporis* (α = 5h 47m.0; δ = − 20° 54').

1900, December 24	− 95 km	Campbell.
December 28	− 97	Campbell.
December 30	− 94	Campbell.

θ Canis Majoris ($\alpha = 6^h\ 50^m$; $\delta = -11°\ 55'$).

1897, December	15	$+96^{km}$	CAMPBELL.
1899, October	16	$+96.0$	WRIGHT.
1900, October	9	$+95.5$	WRIGHT.

I *Pegasi* ($\alpha = 21^h\ 17^m$; $\delta = +19°\ 23'$).

1900, July	3	-75.7^{km}	WRIGHT.
July	8	-74.9	WRIGHT.
July	16	-77.1	WRIGHT.

μ Sagittarii ($\alpha = 18^h\ 7^m.8$; $\delta = -21°\ 05'$).

1899, June	19	-75^{km}	WRIGHT.
1900, May	30	-76	WRIGHT.

These measures are subject to an uncertainty of several kilometers, on account of the character of the spectrum.

The negative sign indicates approach toward the solar system, and the positive sign recession from the solar system.

W. W. CAMPBELL.

NOTE ON THE PROBABLE ERROR OF MICROMETER MEASURES OF *EROS*.

During the recent *Eros* campaign for the determination of the value of the solar parallax, a great many observations were made visually with the micrometer. The question of the accuracy of these measures is therefore an important one. In general, the motion of *Eros* was so rapid in both coordinates that the probable error of the mean of a number of settings, even when made in rapid succession, could not be determined in the usual manner by treating the differences between the single settings and the mean as the v's.

But on December 5, 1900, *Eros* ceased its apparent westward motion among the stars and began to move eastward. Consequently on that date its motion in Right Ascension was very slight — only about twenty-two seconds of arc in eight hours.

On the night mentioned, I measured the position of *Eros* with respect to two small stars in the early evening, when it was from three to two hours east of the meridian, and with respect to two other stars later in the night, when it was from four to five hours west of the meridian. In all I made eighteen measures of difference of Right Ascension, each consisting of ten settings with the micrometer. As the ten settings in no case required more than three and a half minutes, the motion of *Eros* could be entirely neglected and their variations from the mean treated as purely accidental errors of measurements.

In this way I found that the average probable error for the mean of ten settings was $\pm$ 0″.053, the smallest being $\pm$ 0″.036, and the largest 0″.085. During the evening measures the observing conditions were about the average. In the morning the seeing was poor. The average probable error for the evening observations was $\pm$ 0″.046, and for the morning $\pm$ 0″.058. The distances of the stars from *Eros* varied from 19″ to 133″, and their magnitudes from 9.1 to 12. In both evening and morning observations the two comparison-stars were on opposite sides of *Eros* in Right Ascension. Of the one hundred and eighty settings, eight give residuals from the mean of ten that exceed 0″.50, the largest being —0″.67.

As this use of the measures was not thought of until after they had been made, the results here given may be considered as fairly representing the accuracy, so far as accidental error of measurement is concerned, of my entire series of micrometer measures of *Eros*. R. G. AITKEN.

THE CROCKER ECLIPSE EXPEDITION TO SUMATRA.

The Crocker Eclipse Expedition to Sumatra sailed from San Francisco on February 19th, on the Nippon Maru. The expedition is in charge of Acting Astronomer C. D. PERRINE, who is accompanied by Assistant R. H. CURTISS. The Nippon reached Yokohama on March 11th, two days behind schedule time, unusually heavy weather having prevailed almost continuously. A cablegram from Mr. PERRINE was received at the Lick Observatory on April 5th, announcing the arrival of the expedition at Padang. The eclipse occurs May 17, 9^h 29^m P.M., Pacific standard time.

Weather permitting, it is hoped to secure observations with the following instruments:—

1. Five-inch aperture, 40-foot focus, Clark photoheliograph lens, for recording the details of the inner corona. The exposures will vary from ¼ second up to 2½ minutes, the latter on 18 × 22-inch plates.

2. Five-inch aperture, 67-inch focus, Floyd (Clark) photographic telescope, for securing a series of photographs showing the general features of the corona.

3. Six-inch aperture, 32.6-inch focus, Pierson (Dallmeyer) quadruplet camera, for recording the outer portions of the corona.

4. One-inch aperture, 20¾-inch focus camera, with a large double-image prism in front of its lens; separating the two images about 1¼ degrees. It is hoped that a long and a short exposure can be secured in each of five positions of the prism differing 22½ degrees in position-angle from each other, successively.

In this connection, it may be said that no phase of eclipse work is now more prominent or more important than that of measuring the proportion of polarized light in the corona. The outcome of the numerous discussions in the technical journals has simply been to emphasize the necessity of securing more observations with all the instruments heretofore employed for this purpose. I must confess that the polarization effects observed by some at the eclipse of May 28, 1900, are so strong as to excite suspicion that the results are at least in part of instrumental origin. Granting that the coronal light is largely reflected sunlight, it seems to me that the planes of polarization should not be strongly marked. A reflecting or refracting particle of the corona, situated less than 10′ of arc from the Sun's edge, must be receiving illumination from every visible point of the photosphere, and therefore from a multitude of very different directions. Again, the observation includes not only one illuminated point, but a long line of points lying in the line of sight. For regions reasonably near the Sun's edge, how can the planes of polarization be clearly defined to the extent of revealing a large proportion of polarized light?

5. An efficient one-prism spectrograph, slit radial to Sun, for recording the bright and (possible) dark-line spectrum of the corona, and for the bearing of the results on the question of polarization.

6. An efficient one-prism spectrograph, slit tangential to the Sun, to supplement the preceding instrument.

7. A battery of four* photographic telescopes, 3-inch aperture, 11 ft. 4 in. focus, for recording a possible planet (or planets) *Vulcan*. These are mounted in a large polar axis driven by a clock at the end of a 10-foot sector driving-arm, in such a way that two of them will point east of the Sun, and the other two west of it. It is planned to secure photographs in duplicate of a

* Two of the lenses were kindly loaned by Harvard College Observatory.

strip of sky along the Sun's equator about 7° × 35°. Successful photographs should record all stars and planets in this region as bright as the 8.5 magnitude. The instrument was set up at Mt. Hamilton in February, and photographs of this same region of sky were taken without the Sun and the hypothetical planets in it. A comparison of the two sets of plates should promptly lead to the discovery of any planet as bright as the 8.5 magnitude which the Sun may have brought into this region of the sky.

The long duration of this eclipse, 6½ minutes, and the probable darkness of the sky, make this the pre-eminent occasion for the *Vulcan* search by photography. At the eclipses preceding 1900, many observing parties secured photographs for this purpose, with short-focus cameras; but owing to the brightness of the sky, and to the short focal lengths employed, the stars recorded were not fainter than the fourth or fifth magnitude; and no unknown objects were recorded. Several observers appear to have been interested in the problem of recording fainter objects, and to have reached similar solutions almost simultaneously. In the month of January, 1900, Mr. PERRINE came to my office to say that he had designed a telescope for efficiency in searching for *Vulcan*; and I was able to say that I had come to a conclusion on the same question. We compared results, and found them very similar. If I remember correctly, Mr. PERRINE's design called for a 6-inch aperture and 16-foot focus. My dimensions were 5-inch aperture and 15-foot focus. The aim of both had been to reduce the sky-brightness on the plate by increasing the focal length far beyond what we had previously employed at the Indian and other eclipses. On account of the expense of constructing several such instruments, of our distance from manufacturers, of the short duration of the Georgia eclipse ($1^m 25^s$), and of the fact that the expedition would have to start early in April, we decided to plan the instruments for use in Sumatra; and Professor KEELER was spoken to with that in view. Professor WM. H. PICKERING of Harvard College Observatory, was busy at the same time with a practical solution of the same problem. His results, and plans for employing them at the Georgia eclipse, were published in March, 1900; and two of his four lenses are to be used by Mr. PERRINE in Sumatra. We should have liked to secure lenses of about the dimensions originally planned for by Mr. PERRINE and myself; but the uncertainty as to whether observers could be spared for the

Sumatra expedition was not resolved until January, 1901, too late for the full realization of our ideas.

Lenses of the dimensions planned by Professor PICKERING were employed by several parties in 1900; but so far as I am aware no results have been published. W. W. CAMPBELL.

SCIENTIFIC VISITORS TO THE LICK OBSERVATORY.

The Lick Observatory had a pleasant, but far too brief, visit from the members of the U. S. Naval Observatory and Smithsonian Institution Expeditions to Sumatra, on the afternoon of February 14th. The party included Professor A. N. SKINNER, in charge of the U. S. Naval Observatory Expedition, and Mr. C. G. ABBOT, in charge of the Smithsonian Expedition; Professor E. E. BARNARD, of Yerkes Observatory; Professor W. S. EICHELBERGER, and Assistant Astronomers F. B. LITTELL and G. H. PETERS, of the Naval Observatory; Dr. MITCHELL, of Columbia University; Mr. H. D. CURTIS, of the University of Virginia; and Mr. L. E. JEWELL, of Johns Hopkins University.

Mr. W. R. WARNER, of the well-known firm of WARNER & SWASEY, accompanied by Mrs. WARNER, spent the 26th and 27th of March at Mt. Hamilton, much to the gratification of the members of the staff.

It was a pleasure to be able to show Mr. WARNER that the great telescope is in its original satisfactory condition, — perhaps with some improvements added.

Dr. ARTHUR T. HADLEY, President of Yale University, accompanied by Mrs. HADLEY, visited the Observatory on the night of March 27th. W. W. C.

CHANGES IN THE STAFF OF THE LICK OBSERVATORY.

The Board of Regents of the University of California, at the regular quarterly meeting on March 12th, took action affecting the Lick Observatory staff, as follows:—

Assistant Astronomer C. D. PERRINE was relieved from the duties and title of Secretary.

The title of Acting Astronomer was conferred upon C. D. PERRINE, to hold during his absence from the Observatory, on the Crocker Eclipse Expedition to Sumatra.

Mr. RALPH HAMILTON CURTISS, recently Student Assistant in the Students' Observatory of this University, was appointed

Assistant in the Lick Observatory, to date from February 15, 1901. Mr. CURTISS sailed from San Francisco on February 19th, as Assistant on the Crocker Eclipse Expedition to Sumatra, to return to the Observatory about August 1st.

Mr. CORNELIUS GEORGE DALL, recently Student Assistant in the Students' Observatory, was appointed Assistant in the Lick Observatory from March 15 to July 1, 1901.

Mr. ARCHIBALD JETER CLOUD, University of California, Class of 1900, was appointed Secretary of the Lick Observatory, from March 15, 1901. W. W. CAMPBELL.

ASTRONOMICAL TELEGRAMS.

(Translations.)

To Lick Observatory, Mt. Hamilton, Cal.
CAMBRIDGE, MASS., Feb. 22, 1901.
(Received 6:20 A.M., Feb. 24.)

A new star was discovered by ANDERSON at Edinburgh. The position is R. A. 3^h $24^m.4$; Decl. $+ 43° 34'$, in the constellation *Perseus*. The magnitude on Feb. 21, was 2.7; color bluish white. (Signed) EDWARD C. PICKERING.

To W. W. CAMPBELL, Lick Observatory.
FLAGSTAFF, ARIZ., Feb. 23, 1901.
(Received 6:25 A.M., Feb. 24.)

Please verify new star near *Algol*, zero magnitude.
(Signed) A. E. DOUGLASS.

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in carrying out the work of this department. Communications of general interest will be gladly received, and may be sent to SIDNEY D. TOWNLEY, 2023 Bancroft Way, Berkeley, California.

On February 8, 1901, the gold medal of the Royal Astronomical Society was granted to Professor EDWARD C. PICKERING, Director of the Harvard College Observatory.

The Royal Academy of Sciences, Sweden, will hold a special session on October 24, 1901, the tercentenary of the death of TYCHO BRAHE. The society has undertaken to issue a facsimile reproduction of TYCHO'S great work, *Astronomiæ Instauratæ Progymnasmata*, of which but five copies are known to exist.

The following notice is copied from *Science*:—

"Each year there is being issued under the editorship of Professor Dr. W. WISLICENUS, from the press of GEORG REIMER, an *Astronomischer Jahresbericht*, or annual review of all kinds of astronomical publications, including writings on geodesy and navigation, if not too remotely connected with astronomy. This work is carried on under the supervision of the Astronomische Gesellschaft. The first volume contains the publications of 1899, and consists of xxiv + 537 pages, 8vo. This was issued in the spring of 1900.

"In the interests of publishers, of readers, and of the nation which he represents, the associate-editor for the United States desires to make the compilation and review of American publications on the above-named subjects as complete as possible. To this end he invites authors and publishers to favor him with the title and place of publication of each book or article issued during 1901 and each subsequent year, or a copy of the same, if convenient, that it may be reviewed for this purpose. The reviews are merely explanatory — not critical. HERMAN S. DAVIS.

"INTERNATIONAL LATITUDE OBSERVATORY, Gaithersburg, Maryland."

At a recent meeting of the Council of the Astronomical and Astrophysical Society of America it was decided to hold the next meeting of the Society at Washington, D. C., in December, 1901, instead of at Denver, in August. This change will doubtless be agreeable to most of our Eastern friends, but hardly so agreeable to some of us on the Pacific Coast who expected to attend the Denver meeting.

Professor FRANCIS E. NIPHER, of Washington University, has recently made some interesting discoveries in photography, which are of special value with regard to over-exposed solar-eclipse plates. Over-exposed plates can be developed as positives, giving fully as much sharpness and detail as the best negatives. He has found also that plates can, with proper exposure, be developed in direct sunlight. An over-exposed plate may be either developed as a negative in a perfectly dark room or as a positive in a light room. Those interested in the subject may find fuller explanations in a short article by Professor NIPHER, in *Science*, February 8, 1901.

Nova Persei was independently discovered by a number of persons. Professor E. B. FROST, at Dartmouth College, noticed the star on February 22d before having received the message announcing Dr. ANDERSON'S discovery. (See *Astronomical Journal*, No. 493.) The following note from Professor W. J. HUSSEY, who is spending his vacation in Washington, D. C., shows that the star was seen early in that part of the country also:

"The new star in *Perseus*, found by ANDERSON in Scotland, February 21, 1901, was independently discovered in America on the following evening by Mr. RICHARD D. MICOU, a student in the University of Virginia, and by Mr. FARQUHAR, of the Patent Office, Washington, D. C. Mr. FARQUHAR sent a telephone message to the U. S. Naval Observatory announcing his discovery of the new star. Mr. MICOU informed Professor STONE of its existence, who telegraphically announced it to Harvard College Observatory."

During the past three months there has been considerable public discussion concerning the management of the United States Naval Observatory. The naval appropriation bill passed by the last Congress contains the following provision concerning the administration of the affairs of the observatory:—

"There shall be appointed by the President, by and with the advice and consent of the Senate, from persons not officers of the United States, a board of six visitors to the Naval Observatory, four to be astronomers of high professional standing and two to be eminent citizens of the United States. Appointments to this board shall be made for periods of three years, but provision shall be made by initial appointments for shorter terms, so that two members shall retire in each year. Members of this board shall serve without compensation, but the Secretary of the Navy shall pay the actual expenses necessarily incurred by members of the board in the discharge of such duties as are assigned to them by the Secretary of the Navy or are otherwise imposed upon them. The board of visitors shall make an annual visitation to the observatory, at a date to be determined by the Secretary of the Navy, and may make such other visitations, not exceeding two in number annually, by the full board or by a duly appointed committee, as may be deemed needful or expedient by a majority of the board. The board of visitors shall report to the Secretary of the Navy at least once in each year the result of its examination of the Naval Observatory as respects the condition of buildings, instruments, and apparatus, and the efficiency with which its scientific work is prosecuted, and shall also report as respects the expenditures in the administration of the observatory. The board of visitors shall prepare and submit to the Secretary of the Navy regulations prescribing the scope of the astronomical and other researches of the observatory and the duties of its staff with reference thereto. When an appointment or detail is to be made to the office of astronomical director, director of the Nautical Almanac, astronomer or assistant astronomer, the board of visitors may recommend to the Secretary of the Navy a suitable person to fill such office; but such recommendation shall be determined only by a majority vote of the members present at a regularly called meeting of the board held in the city of Washington. The superintendent of the Naval Observatory shall be, until further legislation by Congress, a line officer of the navy, of a rank not below that of captain."

According to the above provisions, President McKinley has appointed the following named persons as members of the Board of Visitors: St. Clair McKelway, of Brooklyn; William R. Harper, President of the University of Chicago; Charles A. Young, Director of the Observatory of Princeton University; Ormond Stone, Director of the Leander McCormick Observatory; Edward C. Pickering, Director of the Harvard College Observatory; Asaph Hall, Jr., Director of the Detroit Observatory.

The affairs of the observatory have not only been publicly discussed, but have become complicated by trouble arising between the Superintendent and the Astronomical Director. Superintendent Davis has preferred charges against Director Brown, and these have been settled, by Secretary Long detaching Professor Brown from duty as head of the Nautical Almanac force. The work of the Almanac is now in charge of Professor Harshman.

During the solar eclipse of May 28, 1900, meteorological data were obtained at various stations. The data have been discussed by Mr. H. Helm Clayton and published in a bulletin of the Blue Hill Meteorological Observatory, Annals of the Astronomical Observatory of Harvard College, Vol. XLIII, No. 1. Some highly interesting conclusions were reached, and Mr. Clayton has published a résumé of the work in the Proceedings of the

American Academy of Arts and Sciences. Vol. XXXVI, No. 16. A review of the latter by Professor R. DE C. WARD, may be found in *Science* for March 1, 1901. Mr. CLAYTON shows that the effect of the decrease in temperature is to form an eclipse cyclone, which travels — that is, forms and dissipates — with the velocity of the shadow. He summarizes his conclusions as follows:—

"In brief, the meteorological effects of the eclipse are important —

"(1) Because they confirm so fully FERREL'S theory of the cold-air cyclone;

"(2) Because they show the wonderful rapidity with which cyclonic phenomena can develop and dissipate in the atmosphere; and

"(3) Because they show that cyclones do not necessarily move with the atmosphere, but move with their originating cause, which in the eclipse had a progressive velocity of about two thousand miles an hour."

Mr. CLAYTON then goes on to consider the subject of diurnal cyclones in the light of the deductions obtained from consideration of meteorological data taken during the eclipse. The thread of Mr. CLAYTON'S argument is sufficiently shown by the following extract:—

"The discovery that the brief fall of temperature attending a solar eclipse produces a well-developed cyclone which accompanies the eclipse shadow, at the rate of about two thousand miles an hour, suggests that the fall of temperature due to the occurrence of night must also produce, or tend to produce, a cold-air cyclone. Since the heat of day produces, or tends to produce, a warm-air cyclone, there must tend to occur each day two minima of pressure, one near the coldest part of the day, and another near the warmest part of the day, with areas of high pressure between them, due to the overlapping of the pericyclones surrounding the cold-air and the warm-air cyclones respectively. These causes must produce entirely or in part the well-known double diurnal period in air-pressure. At any rate, in view of the fact that an eclipse causes a cyclone over half a hemisphere, it will be necessary before rejecting such a theory to show that the fall of temperature at night does not produce a cyclone, or that this cyclone and the corresponding warm-air cyclone of the day do not appreciably influence the barometer.

"The points in favor of the theory that the double diurnal period in pressure is due to two diurnal cyclones, one developed by the cold of night and the other by the heat of day, may be stated in brief as follows: The theory is based on well-known physical laws. The possibility of a cold-air cyclone under conditions similar to the diurnal cyclone is confirmed by the eclipse cyclone. The theory explains the annual oscillation in the time of maxima and minima of pressure in the diurnal period, and explains the occurrence of a third maximum in high northern latitudes in winter. The theory also explains why the warm-air cyclone is well developed over continents, and on clear days, and causes a marked fall in the barometer during the afternoon, while the morning minimum of pressure over continents does not attain an excessive development as compared with that over oceans where there is slight retardation of the air movements on which the fall of the barometer in the cold-air cyclones depends.

"The diurnal cyclones move from east to west, contrary to the motion of ordinary cyclones in temperate latitudes. Their velocity of motion is about one thousand miles an hour at the equator, and diminishes toward the poles."

Father HAGEN, of the Georgetown College Observatory, has published and distributed two charts and catalogues of comparison-stars for *Nova Persei.* These charts and catalogues are very useful and should be obtained by all who have made comparisons of the brightness of the new star. The series of comparisons made at the Students' Observatory, Berkeley, shows that the general decline in the brightness of the star has been varied by frequent increases, the most marked being between March 25th and 26th, when the brightness of the star increased from magnitude 5.1 to magnitude 3.8.

Mr. ANDREW GREIG, of Dundee, Scotland, has kindly forwarded the following:—

ABSTRACT OF A PAPER BY PROFESSOR GRAY ON "THE TIDES AND GENESIS OF THE MOON."

"Professor GRAY, F. R. S., successor to Lord KELVIN at University of Glasgow, lectured recently on 'The Tides and Genesis of the Moon.' The Romans were the first, he said, to detect some of the more prominent of the tidal phenomena, and to assign to these their proper place. He explained and illustrated by means of diagrams the causes of the spring and neap tides, and gave a demonstration of the equilibrium and dynamical theories of the tides. According to the equilibrium theory, there was always high water immediately under the Moon, and also on the opposite side of the Earth at the same time. The motion of rotation of the Earth is retarded by the action between the Earth and the Moon. The Earth rotates, as it were, under the friction-collar formed by the heaped-up waters on the Earth, which are held back by the Moon. Thus, the Earth is, as time goes on, caused to turn on its axis more and more slowly. It is estimated that it falls behind a true clock from this cause by about twenty-two seconds in one hundred years. The action of the Earth upon the Moon was to hasten it in its orbit, so that it was moving outward, increasing the radius of the circle. The consequence was that the length of the day and the length of the month were both increasing; but the length of the day was increasing faster than the length of the month, and thus they were approaching slowly to an equality. When that took place, there would be another change. In consequence of the action of the Sun on the tides upon the Earth, the Moon would begin to come closer in upon the Earth, and unless some other action took place upon the system, the Moon would approach the Earth until it actually fell upon its surface. But we need be under no apprehension as to this happening — it would be several millions of years before such a catastrophe took place.

"With respect to the origin of the Moon, the Earth at an early stage of its existence was a semi-solid, semi-fluid, plastic mass, spinning round on its axis in a period of three to five hours. The period in which a wave would have gone round the Earth would have been about three hours, or nearly equal to the period in which the Earth went spinning round. Now, if a wave produced by the action of the Sun went round the Earth in three hours, each time it returned to receive the Sun's action it would be increased in size. The Earth was spinning at a great rate; and the result would be that parts of it would fly off like the rim of an over-driven fly-wheel, and one or more of these fragments formed the Moon. The Moon continued to go round in a similar orbit to the Earth, but rather more slowly than when it left the Earth. Immediately it began to go further and further out, and this was what it was still doing."

The value of *Eros* for the redetermination of the solar parallax has been noted repeatedly in these *Publications*. But it holds other attractions for astronomers as well. Professor PICKERING early pointed out that it was well situated for the investigation of certain photometric problems; for instance, whether the light of a planet varied inversely as the square of the distance. And now observers with the photometer find that the light of the little planet varies considerably in a very short period of time. Dr. E. VON OPPOLZER seems to have been the first one to call attention to this interesting phenomenon, but his announcement in the *Astronomische Nachrichten* received prompt confirmation from a number of other observers.

From observations so far published the range of variation seems to be considerably greater than one magnitude, and the interval from maximum to maximum or from minimum to minimum to be less than three hours. It has been suggested that the variation is due to the rapid rotation of *Eros* — the opposite hemispheres of the little planet being assumed to possess different albedos, or powers of reflecting light.

Mr. ST. CLAIR MCKELWAY, of Brooklyn, has declined the tender of a place on the Board of Visitors of the United States Naval Observatory, and Secretary LONG has designated for the place Professor CHARLES F. CHANDLER, of Columbia University, New York, who has accepted.

Minutes of the Meeting of the Board of Directors, held in the Rooms of the Society, March 30, 1901, at 7:30 P. M.

Mr. Burckhalter presided. A quorum was present. The minutes of the last meeting were read and approved. The following members were duly elected:—

List of Members Elected March 30, 1901.

Mr. Geo. L. Dillman, C. E.	917 Grand St., Alameda, Cal.
Mr. Edward Irving	Berkeley, Cal.
Lowell Observatory	Flagstaff, Arizona.

Report of the Library Committee.

We, the undersigned Committee of the Society's Library, report as follows:—

During the past year the card index (which was commenced some years ago) of the bound volumes of the library, has been completed. The library now contains 1,144 bound volumes. It is hoped that we may soon commence an index for the pamphlets.

The expenditures from the Alexander Montgomery Library Fund for the year ending March 30, 1901, may be found in the Treasurer's report.

Respectfully submitted,

Sidney D. Townley, *Librarian.*
Rose O'Halloran,
Adelaide M. Hobe.

The following resolutions were, on motion, adopted:—

Resolved, That the chairman of the Committee on Publication be not required to pay annual dues.

Resolved, That the Library Committee be empowered to dispose of extra copies of certain books, by sale or exchange, provided the number of copies be not reduced to less than two of each.

Resolved, That the Library Committee be authorized to purchase such additional book cases and shelves as are required; the sums expended not to exceed the amount of interest available.

Adjourned.

Minutes of the Annual Meeting of the Astronomical Society of the Pacific, held in the Rooms of the Society, March 30, 1901, at 8 P. M.

The meeting was called to order by Mr. Burckhalter. A quorum was present. The minutes of the last meeting were approved. The Secretary read the names of new members duly elected at the Directors' meeting.

The following papers were presented:—

1. Reports of Committees: on Nominations; on the Comet Medal; on Auditing; and Annual Report of the Treasurer.
2. Photographs of the Zodiacal Light, by A. E. Douglass.
3. Photographic Observations of Comet II, 1900, by H. K. Palmer.
4. Planetary Phenomena for May and June, 1901, by M. McNeill.

The Committee on Nominations reported a list of names proposed for election as Directors, as follows: Messrs. A. H. Babcock, W. W. Campbell, Chas. S. Cushing, John Dolbeer, C. B. Hill, E. J. Molera, Miss R. O'Halloran, Messrs. C. D. Perrine, Wm. M Pierson, S. D. Townley, F. R. Ziel.

For Committee on Publication: Messrs. R. G. Aitken, S. D. Townley, J. D. Galloway.

Messrs. Moses and Galloway were appointed as tellers. The polls were open from 8:15 to 9 P. M., and the persons above named were duly elected to serve for the ensuing year.

Report of the Committee on the Comet-Medal, Submitted March 30, 1901.

This report relates to the calendar year 1900. The comets of 1900 have been:

Comet *a* (unexpected comet), discovered by M. Michel Giacobini, at the Nice Observatory, on January 31st.

Comet *b* (unexpected comet), discovered by M. Borrelly, at the Marseilles Observatory, on July 23d, and independently, a little later on the same night, by Dr. Brooks, of Geneva, N. Y.

Comet *c* (unexpected comet), discovered by M. Michel Giacobini, at the Nice Observatory, on December 20th.

The Comet-Medal has been awarded to the discoverers of comets *a* and *c*, and to the first discoverer of comet *b*, in accordance with the regulations.

Respectfully submitted,

W. W. Campbell,
Wm. M. Pierson,
Chas. Burckhalter.

The Treasurer submitted his Annual Report as follows:—

ANNUAL STATEMENT OF THE RECEIPTS AND EXPENDITURES OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC FOR THE FISCAL YEAR ENDING MARCH 30, 1901.

GENERAL FUND.

Receipts.

Cash Balance, April 1, 1900		$35 0
Received from dues	$ 831 44	
" " sale of publications	22 50	
" " " " stationery	1 55	
" " advertisements	30 00	
" " Security Savings Bank (interest)	28	
" " Life Membership Fund (loan)	500 00	
" " " " " (interest)	63 58	
" " Donohoe Comet-Medal Fund (engraving four medals, Nos. 36 to 39)	4 00	1,453 35
		$1,488 44

Expenditures.

For publications: printing		$744 55		
" " illustrations	$62 57			
Less payment by Lick Observatory	10 00	52 57		
			$797 12	
Stationery and printing			96 85	
Postages			68 23	
Rent			180 00	
Salary Secretary-Treasurer			180 00	
Expressages			17 98	
Janitor and elevator			6 25	
Gas			85	
Taxes			2 45	
Insurance premiums			22 45	
Telegrams and telephoning			3 05	
Lantern at two lectures			17 00	
Engrossing resolutions and diplomas			20 00	
Dry plates			2 25	
Engraving two comet medals (Nos. 38 and 39)			2 00	
Bank exchanges			77	1,417 25
Cash Balance, March 30, 1901				$71 19

LIFE MEMBERSHIP FUND.

Cash Balance, April 1, 1900		$2,103 95
Interest for 1900		63 58
		$2,167 53
Less transfer to General Fund (interest)	$63 58	
" " " " " (loan)	500 00	563 58
Cash Balance, March 30, 1901		$1,603 95

DONOHOE COMET-MEDAL FUND.

Cash Balance, April 1, 1900	$665 69
Interest for 1900	22 44
	$688 13
Less transfer to General Fund (engraving four medals, Nos. 36 to 39)	4 00
Cash Balance, March 30, 1901	$684 13

BRUCE MEDAL FUND.

Cash Balance, April 1, 1900		$2,500 00
Interest for 1900		77 97
Cash Balance, March 30, 1901		$2,577 97

ALEXANDER MONTGOMERY LIBRARY FUND.

Cash Balance, April 1, 1900		$1,523 11
Interest for 1900		50 55
		$1,573 66
Less expenditures: Hicks-Judd Co., for binding	$13 15	
Physical Review and *American Mathematical Soc'y.*	8 60	
Vierteljahres Schrift	63	
Popular Astronomy, subscription (Vols. 8 and 9)	5 00	
Observatory (14 numbers)	3 02	30 40
Cash Balance, March 30, 1901		$1,543 26

FUNDS.

Balances on Deposit as follows:

General Fund:		
with Donohoe-Kelly Banking Co	$61 15	
" Security Savings Bank	10 04	
		$71 19
Life Membership Fund:		
with San Francisco Savings Union	$553 95	
" German Savings and Loan Society	450 00	
" Hibernia Savings and Loan Society	600 00	
		$1,603 95
Donohoe Comet-Medal Fund:		
with San Francisco Savings Union	$225 98	
" German Savings and Loan Society	223 75	
" Hibernia Savings and Loan Society	234 40	
		$684 13
Alexander Montgomery Library Fund:		
with San Francisco Savings Union	$489 90	
" German Savings and Loan Society	430 18	
" Hibernia Savings and Loan Society	623 18	
		$1,543 26
Bruce Medal Fund:		
with San Francisco Savings Union	$1,287 81	
" Security Savings Bank	643 90	
" German Savings and Loan Society	646 26	
		$2,577 97
		$6,480 50

SAN FRANCISCO, March 30, 1901.

F. R. ZIEL, *Treasurer.*

Examined and found correct.

W. H. LOWDEN, F. H. MCCONNELL, } *Auditing Committee.*

The Committee appointed to audit the Treasurer's accounts reported as follows, and the report was, on motion, accepted and adopted:—

To the President and Members of the Astronomical Society of the Pacific:

GENTLEMEN—Your committee appointed to audit the accounts of the Treasurer for the fiscal year ending March 30, 1901, have made a careful examination, and find same to be correct.

Yours respectfully,

W. H. LOWDEN,
F. H. MCCONNELL.

March 30, 1901.

The Secretary reported that a bronze replica of the Emperor-Nicolai-Alexandrovich-Medal has been presented to the Society by the Russian Astronomical Society. The thanks of the Society were returned to the donors.

The following resolution was, on motion, adopted:—

Resolved, That all the acts appearing in the minutes of the meetings of the Board of Directors of this Society, as having been done by said Board during the past fiscal year, are here now, by this Society, approved and confirmed.

Adjourned.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, MARCH 30, 1901, AT 9:30 P. M.

The new Board of Directors was called to order by Mr. TOWNLEY. A quorum was present. The minutes of the last meeting were approved.

The business in hand being the election of officers and committees for the ensuing year, the following officers and committees, having received a majority of the votes cast, were duly elected:—

President: Mr. JOHN DOLBEER.
First Vice-President: Mr. S. D. TOWNLEY.
Second Vice-President: Miss R. O'HALLORAN.
Third Vice-President: Mr. CHAS. S. CUSHING.
Secretaries: Messrs. C. D. PERRINE and F. R. ZIEL.
Treasurer: Mr. F. R. ZIEL.

Committee on the Comet-Medal: Messrs. CAMPBELL *(ex-officio)*, PIERSON, and BURCKHALTER.

Library Committee: Mr. TOWNLEY, Miss O'HALLORAN, Miss HOBE. Mr. TOWNLEY was appointed Librarian.

The President was authorized to appoint the members of the Finance Committee, and accordingly made the following selection:—

Finance Committee: Messrs. PIERSON, HILL, CUSHING.

The Committee on Publication is composed of: Messrs. R. G. AITKEN, S. D. TOWNLEY, J. D. GALLOWAY.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. [illegible]	*President*
Mr. [illegible]	*First Vice-President*
Miss [illegible]	*Second Vice-President*
Mr. [illegible]	*Third Vice-President*
Mr. [illegible] Mr. [illegible]	*Secretaries*
Mr. [illegible]	*Treasurer*

Board of Directors—[illegible] Hill, Molera, [illegible]

[illegible]

[illegible]

[illegible]

[illegible] Burckhalter.

OFFICERS OF THE CHICAGO SECTION

[illegible]

OFFICERS OF THE MEXICAN SECTION.

[illegible]

NOTICE.

The attention of new members is [illegible] of the By-Laws, which provides [illegible] Subsequent [illegible] This rule is [illegible] Market Street, San Francisco. [illegible]

[illegible]

[illegible] Secretaries. [illegible]

[illegible]

PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME XIII.

NUMBER 79.

1901.

SAN FRANCISCO:

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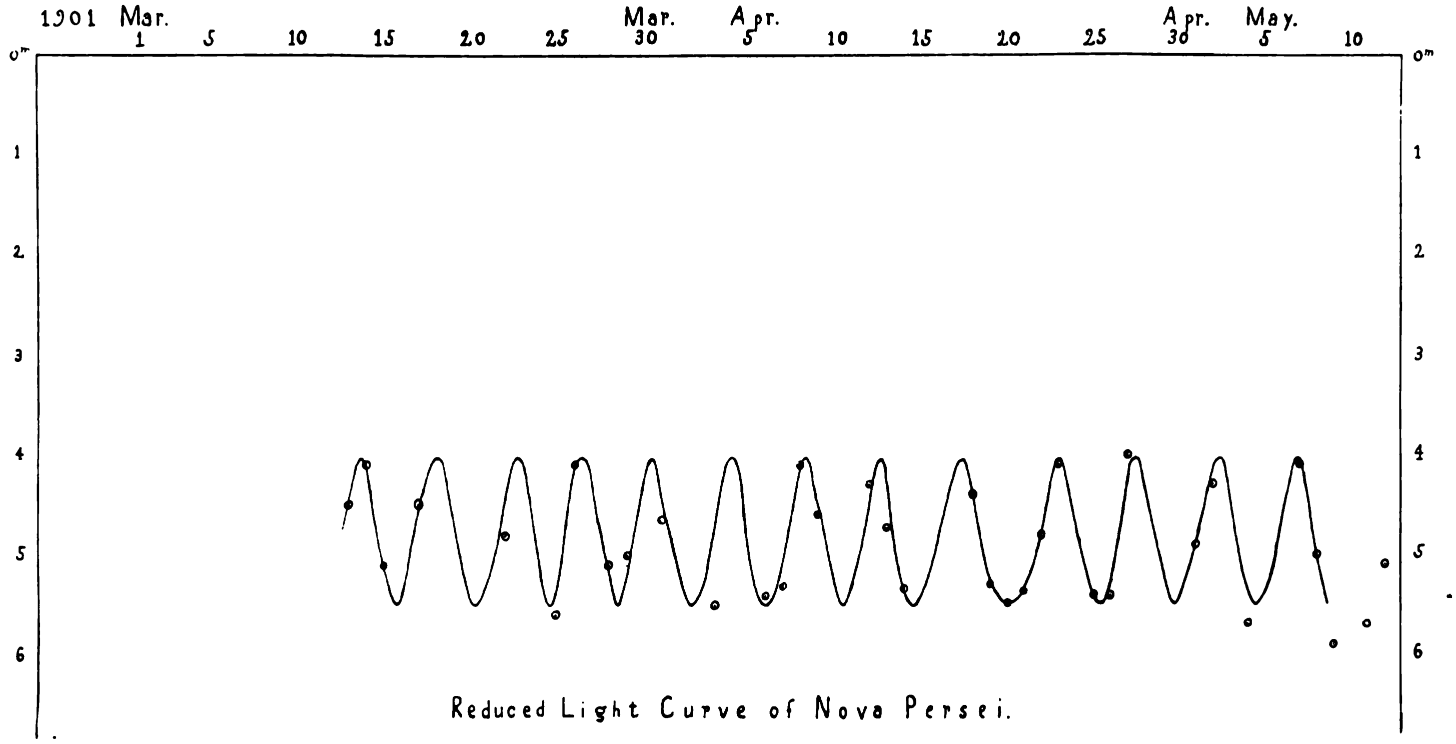

Reduced Light Curve of Nova Persei.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

Vol. XIII. San Francisco, California, June 1, 1901. No. 79.

LIGHT CURVE OF *NOVA PERSEI.*

By Sidney D. Townley.

The new star in *Perseus* was observed at the Students' Observatory on nearly every clear night from February 24th to May 12th. Unfortunately obstructions in the northwestern horizon made it impossible to continue observations after the latter date. It was early noticed that the general decline of the star's brightness was interrupted by frequent increases of brightness. Toward the end of March the results gave strong evidence of a periodicity in the light changes, but it was not until the latter part of April that a sufficient number of observations had been obtained to warrant the announcement that *Nova Persei* had become a variable star of short period. On April 27th Professor Leuschner sent the following telegram, in cipher, to the Harvard College Observatory:—

"Maxima of *Nova Persei* were observed at Berkeley by Townley, March 14th, March 26th, April 8th, and April 23d. Range, 1.3 magnitudes. Two, possibly three, secondary maxima."

We were informed that information to the same effect had already been received at Harvard College Observatory from Kiel, and consequently this telegram was not distributed by Professor Pickering.

Subsequent observations have shown that the secondary maxima are probably of the same magnitude as the others, thus giving a period of about 4½ days from March 13th onward. No definite period can as yet be made out from the small fluctuations noticed previous to that time. The observations made subsequent to March 13th are represented in the accompanying figure; the general decline in brightness having been eliminated in the following way. When the observations were plotted the following maxima were noticed:—

March	14,	$3^m.1$	April	23,	$4^m.3$
"	26,	3 .7	May	7,	4 .3
April	8,	4 .1			

The maximum of March 14th was first brought down to that of March 26th by adding 0.6 magnitude to the value for March 14th and to each observation between March 14th and 26th $0^m.6$ times the ratio of "interval from date of observation to March 26th" and "twelve days." These magnitudes were then increased by the constant amount $0^m.4$ to bring them to the level of the maximum of April 8th. The observations between March 26th and April 8th were increased by proportional parts of $0^m.4$ in the same way as above. Magnitudes from April 8th to 23d were decreased by proportional parts of $0^m.2$, and all magnitudes after April 23d were decreased by $0^m.2$. Thus the five maxima were all brought to the same level, and the plotted result is seen in the accompanying figure. An inspection shows that the observations are very well represented by a curve which shows slight deviations from a symmetrical curve of a period of about 4.6 days. Very few portions of the curve have no observations to depend upon. The last six observations are somewhat uncertain on account of the small altitude, twilight, obstructing trees, etc. They seem to indicate that the general decline at that time was much more than $0^m.2$ of a magnitude. The twelve periods of the curve extend over 54.5 days, which gives 4.54 days for the average period; but if the last nine only are taken, a period of 4.61 days is obtained. The latter observations show a tendency towards a lengthening of the period. The information from Kiel, which was received here about May 5th, reported a three-day period between March 20th and 30th, when observations here were unfortunately interrupted by bad weather. A month later, however, my observations on ten consecutive days, April 18th to 27th, except April 24th, show clearly that a three-day period did not then exist.

The curve must not be taken too literally. It is not very likely that all of the maxima were of exactly the same height, nor all of the minima of the same depth, as is indicated in the curve drawn. The observations seem to show, too, that some of the turning-points are quite sharp and others rather flat, but the number of observations at present available would not justify an attempt to draw anything more than a general curve. Although the period of this variable is short, still it is not likely that it will show the marked characteristic, great regularity, of the two classes of short-period variables. It will be found rather, I think, to behave like the long-period variables in which exact uniformity of changes is always lacking. The second, third, fifth, and sixth maxima; the first, second, fifth, and seventh minima have but few observations to support them, and I should not be surprised to see these parts of the curve considerably modified when other observations become accessible.

OBSERVATIONS.

The observations were made by the same methods that I have used in previous variable star-work, and which are fully explained in the Publications of the Washburn Observatory, Vol. VI, Part 3. Both of the standard methods were used. After the first few nights the comparison-stars employed were selected from the charts and catalogues sent out from the Georgetown College Observatory. The magnitudes of the comparison-stars have been carefully investigated. After examining several sources, it was decided to use the magnitudes given in the later volumes of the Harvard College Observatory photometric work. It is essential that the magnitudes adopted shall conform to some definite system, and this can be obtained better perhaps by taking the results of one investigation than by combining the results of several; at least the latter method could be made the more efficient only by an elaborate discussion, which it did not seem necessary to make at this time. The comparison-stars used are given in the following table; the adopted magnitudes having been obtained from volumes 44 and 45 of the Annals of the Harvard College Observatory. The magnitude of ρ *Persei* was obtained from comparisons on March 10th, 11th, 12th, and 14th.

COMPARISON - STARS.

Reference Letter.	Star.	Adopted Magnitude.	Reference Letter.	Star.	Adopted Magnitude.
a	α *Aurigæ*	0.24	*f*	α *Geminorum*	1.61
b	β *Orionis*	0.30	*g*	α *Persei*	1.85
c	α *Canis Minoris* ..	0.46	*h*	β *Andromedæ*	2.17
d	α *Tauri*	1.09	*i*	α *Ursæ Minoris* ..	2.20
e	β *Geminorum*	1.25	*j*	γ *Cassiopeiæ*	2.22

Reference Letter.	Star.	Adopted Magnitude.	Reference Letter.	Star.	Adopted Magnitude.
k	γ *Andromedæ*.....	2.26	*s*	ρ *Persei*.........	3.42
l	β *Persei*..........	2.30	*t*	ν *Persei*.... ...	3.90
m	β *Cassiopeiæ*.....	2.44	*u*	κ *Persei*	4.04
n	δ *Cassiopeiæ*.....	2.78	*w*	ι *Persei*.........	4.20
o	ζ *Persei*.........	2.83	*x*	*Flamsteed 32*....	5.13
p	ε *Persei*.........	2.88	*y*	*Flamsteed 36*....	5.33
q	γ *Persei*.........	3.05	*z*	*Flamsteed 30*....	5.39
r	δ *Persei*.........	3.06	*a'*	B. D. + 44° 734	6.48

Following are the observations upon which the foregoing results depend. The weights of the individual observations have been assigned, arbitrarily, after considering the circumstances and conditions under which the observations were made. The chief factors which affect the accuracy of such observations are: distance between the stars compared; number of steps estimated, or difference in magnitude of the two comparison-stars used; difference in color of the stars. The observations made by the step-method have been reduced on the assumption that one step equals one tenth of a magnitude, which seems justified by the fact that in the long series of observations made at the Washburn Observatory several years ago, the value of one step was found to be 0.92 of a magnitude. v stands for *Nova Persei*. In the column headed "instrument," E stands for naked-eye observations; G for field-glasses; F for 4.5 centimeter finder of equatorial; S for surveyor's transit; C for 15.4 centimeter Clark equatorial.

OBSERVATIONS.

Date. G. M. T.	Comparisons.	Nova.	Wt.	Weighted Mean.	Instrument.	Remarks.
1901		m		m		
Feb 24.69...	v $\overline{\underline{<}}$ b	0.35	2	...	E	
	a 5 e	0.75	2	...	E	
	a 3–4 e	0.59	2	...	E	Made by R. A. Curtis
	a 2–3 i	0.73	1	0 6	E	
Feb. 25.69...	b 3 i	0.84	1	...	E	
	a 8–9 e	1.10	2	...	E	
	v = e	1.25	1	...	E	Position difficult.
	b 6–5 l	0.73	1	...	E	Moon interferes.
	c 6 d	0.84	1	1.0	E	Moon interferes.

Date. G. M. T.	Comparisons.	Nova.	Wt.	Weighted. Mean.	Instrument.	Remarks.
1901		m		m		
26.77...	d 3-4 i	1.47	2	...	E	
	b 8 i	1.84	1	...	E	
	e 5 i	1.72	2	...	E	
	e 4 f	1.78	2	1.7	E	
27.63...	d 8-9 i	2.03	2	...	E	
	v = g	1.85	3	...	E	
	d 7 k	1.91	2	...	E	
	h 4 k	2.21	2	2.0	E	
1.65...	g 7-8 l	2.19	...	2.2	E	Clouds prevent other observations.
2.65...	g 4 l	2.03	2	...	E	
	g h 1 k v 2 l	2.10	4	...	E	
	i 2 v	2.40	1	2.1	E	
3.67...	l 3 p	2.47	1	...	E	
	l 1-2 r	2.41	1	...	E	
	g 2 h i 1 k 2 l 2 v	2.60	3	2.5	E	
4.65...	g 3 r	2.21	1	...	E	
	g 3 p	2.16	1	...	E	
	4 n	2.44	1	2.3	E	
5.65...	v l j	2.26	5	...	E	v as red as d.
	m 1 v	2.44	2	...	E	
	i 1-2 v	2.35	2	2.3	E	
6.65...	v 3 s	3.12	1	...	E	
	l 7 s	3.08	1	3.1	E	
8.63...	l 4 s	2.74	...	2.7	E	
10.75...	l 3-4 s	2.69	1	...	E	
	n 2 v	2.98	2	...	E	
	l 7-8 p	2.73	3	...	E	
	l 7 r	2.83	3	2.8	E	
11.69...	l 9 s	3.32	1	...	E	
	v 1 s	3.32	1	...	E	
	r 1 v	3.16	3	...	E	
	p 2-3 v	3.13	2	...	E	
	p 4 u	3.34	1	3.2	E	
12.75...	p v 2 r	2.87	4	...	E	
	p 1 u	3.00	1	...	E	
	q 1-2 v	3.20	2	...	E	
	l 6 s	2.97	1	3.0	E	
13.7 ...	p 4 u	3.34	2	...	E	
	r 5-6 u	3.60	3	...	E	
	p 5 t	3.39	2	...	E	
	r 6-7 t	3.60	3	3.5	E	

Date. G. M. T.	Comparisons.	Nova.	Wt.	Weighted. Mean.	Instrument.	Remarks.
1901		m		m		
Mar. 14.71...	r 1 v	3.16	3	...	E	
	p 2 t	3.08	3	...	E	
	q 1 v	3.15	2	...	E	
	l 7 s	3.08	1	...	E	
	o v	2.83	2	3.1	E	Stars twinkle ba
Mar. 15.77...	u 2 t 1 v	4.14	...	4.1	G	
Mar. 17.71...	r 7 t	3.65	3	...	G	
	r 5 u	3.55	3	...	G	
	p 7 t	3.59	3	...	G	
	p 5 u	3.46	2	3.6	G	
Mar. 22.74...	v w	4.20	3	...	G	
	u 3 x	4.37	2	...	G	
	t 2–3 v	4.15	2	4.2	G	
Mar. 25.65...	x 1 v	5.23	2	...	G	
	u 7–8 z	5.05	1	...	G	Difficult with fi
	x 2 y	5.17	2	5.2	G	glasses.
Mar. 26.71...	v 2 u t	3.77	2	...	F & S	
	r 6–7 u	3.70	1	3.7	F & S	
Mar. 28.67...	u 6–7 x	4.75	1	...	G	
	t 7–8 x	4.82	1	4.8	G	
Mar. 29.69...	u 5 x	4.59	1	...	G	
	t 7 x	4.76	1	4.7	G	
Mar. 31.67...	u 3 x	4.37	1	...	G	
	t 4 x	4.39	1	4.4	G	
Apr. 3.66...	x 3–4 z	5.22	3	...	G	Difficult with fi
	y 3 v	5.66	1	5.3	G	glasses.
Apr. 6.7 ...	x 8 z	5.34	3	...	G	v just visible wi
	v 2 z	5.19	2	...	G	glasses.
	v z	5.33	3	5.3	G	
Apr. 7.7 ...	x 8 z	5.34	1	...	G	
	v y	5.33	1	5.3	G	
Apr. 8.70...	t 1 u 1 v	4.12	...	4.1	G	
Apr. 9.67...	t 6–7 x	4.70	1	...	G	
	u 5 x	4.59	1	4.6	G	
Apr. 12.7 ...	u 2–3 v	4.29	...	4.3	G	Uncertain on ac of clouds.
Apr. 13.69...	t 7 x	4.76	1	...	G	
	u 7–8 x	4.85	1	4.8	G	
Apr. 14.67...	v y	5.33	2	...	G	
	z 2 v	5.59	1	5.4	G	

e. . T.	Comparisons.	Nova.	Wt.	Weighted. Mean.	Instrument.	Remarks.
1		m		m		
l.67...	u 5 x	4.59	1	...	F	
	t 4 x	4.38	1	4.5	F	
ı.67...	v z	5.39	3	...	G	
	y 2 v	5.53	2	5.4	G	
ı.67...	z 2 v	5.59	...	5.6	G	
.67...	v z	5.39	2	...	F	
	y 2 a′	5.56	1	...	F	
	y 2–3 v	5.58	1	5.5	F	
.68...	v 1 x	5.03	3	...	F & C	
	u 8 x	4.91	2	5.0	F & C	
; 67...	t 3 x	4.27	1	...	F & C	
	u 2 x	4.26	1	4.3	F & C	
;.68...	y 2 a′	5.56	1	...	F & C	
	z 2–3 v	5.64	1	5.6	F & C	
;.67...	y 3–4 a′	5.73	2	...	F & C	
	z 2 v	5.59	3	5.6	F & C	
7.67...	t 3–2 x	4.21	1	...	G F & C	
	u 2 x	4.26	1	...	G F & C	
	u 2 v	4.24	1	4.2	G F & C	
:.67...	v x	5.13	...	5.1	F & C	
:.68...	t 5 x	4.51	1	...	F & C	
	u 4 x	4.48	1	4.5	F & C	
l.68...	y 7 a′	6.14	1	...	F & C	Seeing poor.
	z 3–4 v	5.74	1	5.9	F & C	
'.68...	t 3 x	4.27	1	...	F	
	u 2–3 x	4.26	1	4.3	F	
l.68...	x 5 y	5.23	...	5.2	F & C	
).68...	y 7 a′	6.14	...	6.1	F & C	Difficult—low altitude.
:.68...	y 5 a′	5.90	...	5.9	F & C	Very uncertain.
ı.68...	v y	5.33	..	5.3	F & C	Very uncertain.

NOTE.—Since the above was written I have received through the courtesy of Director CAMPBELL, of the Lick Observatory, the results of a very complete series of observations made by Mr. AITKEN. Bulletin No. 17 of the Yerkes Observatory, containing Mr. PARKHURST's observations, and No. 6, Vol. LXI, *Monthly Notices of Royal Astronomical Society*, containing observations by the Oxford observers, have been received also. These observations have been plotted, and in genera confirm the curve from March 20th on, strengthening many of its weal points. The eighth and eleventh maxima and the twelfth minimum ar the only ones which are not strengthened by additional observations Between March 10th and 16th, however, the observations do not suppor the curve as drawn. They show either a period of about one day, o else some large errors of observation. My observation of April 3d which falls considerably from the curve, is confirmed by one made b Mr. PARKHURST showing that the minimum was delayed about a day.

These additional observations show, as I expected they would, tha the actual curve is considerably more irregular than the one drawn.

Mr. AITKEN'S observations, which extend to May 19th, give tw additional maxima, May 13.5 and about May 18.5, the last on the curve o the accompanying figure being May 7.7, G. M. T. This shows almost con clusively, what was previously suspected, that the period is lengthening

A preliminary investigation of all the data available leads to th following conclusions:—

1. From February 24th to March 19th the brightness of the sta decreased in an irregular way about three magnitudes, but there is stron evidence of a gradually lengthening period throughout this time. . period of about a day from March 10th to 15th seems almost certain.

2. From March 20th to May 19th there was a very slight gener decline in brightness, but a well-marked period, which gradually lengtl ened from three and a half to five days. The range between maxin and minima has an average value of about 1.5 magnitudes.

A modification of the tide theory offers an explanation of the ph nomena observed in *Nova Persei*. Suppose a near approach betwee two bodies occurs; one a body of large mass, which has cooled so tha a thin crust has been formed, making the body non-luminous, a conditic in which it is thought our Sun will be about 20,000,000 years hence; th other a body of small mass and solid, like the Moon, for example. L the directions and velocities of motion of these two bodies be such tha a very close approach, not a collision, takes place. Suppose the masse of the bodies are such that the larger is not sensibly disturbed in i motion, but that the smaller is profoundly disturbed. Its orbit will b changed from a straight line to a parabola, an hyperbola, or a very elon gated ellipse, depending upon the initial velocity. At a very nea approach of the two bodies the smaller will be swept rapidly around th larger, like a comet around the Sun; the attraction of the smaller ma be sufficient to burst the crust of the larger and produce a sudden ou burst of the heated matter within. As the smaller body moves rapid around the larger, this rent in the crust will be carried forward and th light of the star will increase rapidly, and a tremendous tidal-wave wi have been set up. As the smaller body moves away from the larger, th tidal-wave will continue to move, sweeping away the accumulated vapor thus producing a maximum of brightness at each return of the wave to th line of sight of the observer. On account of internal friction, howeve the velocity of propagation of this wave will continually decrease an the period of fluctuation in brightness will gradually increase, and th star will finally settle down to its former state.

This explanation is offered tentatively. I hope soon to thoroughl investigate the suggestions here made.

A REVIEW OF THE "CHAPTERS ON THE STARS" BY PROFESSOR SIMON NEWCOMB, IN THE *POPULAR SCIENCE MONTHLY*, JULY, 1900,—MARCH, 1901.

BY J. D. GALLOWAY.

In the *Popular Science Monthly* for March of this year, there is concluded a notable contribution to the literature of popular astronomy in the "Chapters on the Stars" by Professor SIMON NEWCOMB. Professor NEWCOMB has reviewed the entire field of our knowledge of the stars, and has presented the subject with the least use of technical terms and demonstrations possible, in order to conform to the general character of the magazine in which the articles appeared. This has not, however, prevented him from dealing with the subject in the clear and lucid manner which characterizes his other works on similar subjects.

Beginning with the statements as to our knowledge of the southern heavens some thirty years ago, he traces the historical development of that work, referring especially to the history of Cordoba Observatory in the Argentine Republic, under GOULD, that of the Royal Observatory at the Cape of Good Hope, under GILL, and of the Observatory of Harvard University at Arequipa, Peru.

The development of the spectroscope is then referred to with the advancement made in the measurement of star-motions in the line of sight, originating with Sir WILLIAM HUGGINS and now being so successfully carried on by CAMPBELL. Following this, is a short discussion of the comparative dimensions of the solar system and its position among the stars.

MAGNITUDES OF THE STARS.

The second chapter deals with the magnitudes of the stars. A description of the photographic and photometric systems of measurement is given and the difficulties of both are mentioned. The magnitude of the Sun, based on the results of WOLLASTON, BOND, and ZÖLLNER is —26.4, from which it results that the Sun gives us 10,000,000,000 times the light of *Sirius*, the brightest star, and 91,000,000,000 the light of a star of magnitude one. To make our Sun shine with the intensity of the light of *Sirius*, it would be necessary to remove it to a point 100,000 times its present distance from us. A conclusion drawn from these researches is that our Sun is smaller than the brighter of the stars.

CONSTELLATIONS AND STAR-NAMES.

The subject of the constellations and the names of the stars receives considerable attention. Of the constellations, the astronomical world now recognizes eighty-nine, four being counted in the subdivided constellation of *Argo* as arranged by Dr. GOULD. Considerable confusion still exists as to the boundaries of the constellations and the names of some of the stars in them. The method BAYER originated in 1601, which gives stars the names of the letters in the Greek alphabet, is followed.

CATALOGUING AND NUMBERING THE STARS.

A description of the method of locating the position of stars by Declination and Right Ascension is given, together with an historical review of the efforts to catalogue the stars. PTOLEMY, who lived A. D. 150, made a catalogue of 1,030 stars, but the roughness of his instruments introduced considerable error into the results. The catalogue of ARGELANDER and SCHÖNFELD, extending to 22° of South Declination, enumerates 310,000 stars, while the work as continued at the Cordoba Observatory from this point to 42° South Declination gives 340,000 more. The entire work would give more than 800,000. Photographic catalogues of the southern heavens have been made by GILL, but the work of making a photographic map of the entire heavens is now being carried out as an international enterprise, with headquarters at Paris, instruments of a uniform plan being made for the purpose. For the number of lucid stars, PICKERING gives 5,333, while SCHIAPARELLI counts 4,303. If the results of the *Durchmusterung* of Cordoba Observatory be extended to the entire sky, the number of stars down to the tenth magnitude is 2,311,000; but this is open to doubt. The international photographic chart must be completed before a correct estimate of the number of stars can be made.

THE SPECTRA OF THE STARS.

One of the principal branches of modern astronomy is that of spectroscopy, and considerable space is devoted to an explanation of the principles underlying the spectroscope. Plates of the spectra of some of the larger stars accompany the text, and the chapter closes with the statement that "the most interesting conclusion drawn from observations with the spectroscope is that the stars are composed, in the main, of elements similar to those found in our Sun. As the latter contains most of the elements found on the Earth, and few or none not found there, we may say that Earth and stars seem to be all made out of like matter. It is, however, not yet easy to say that no elements unknown on the Earth exist in the heavens. It would scarcely be safe to assume that, because the line of some terrestrial substance is found in the spectrum of a star, it is produced by that substance. It is quite possible that an unknown substance might show a line in appreciably the same position as that of some substance known to us. The evidence becomes conclusive only in the case of those elements of which the spectral lines are so numerous that when they all coincide with lines given by a star, there can be no doubt of the identity."

PROPER MOTION OF THE STARS.

The question as to the motion of the stars is answered by Professor NEWCOMB in the affirmative. In the chapter on the proper motion of the stars, he says:—

"We may assume that the stars are all in motion. It is true that only a comparatively small number of stars have been actually seen to be in motion; but as some motion exists in nearly every case where observations would permit of its being determined, we may assume the rule to be universal."

Yet this motion is very slight, and

"If HIPPARCHUS or PTOLEMY should rise from his sleep of 2,000 years — nay, if the earliest priests of Babylon should come to life again and view the heavens, they would not perceive any change to have taken place in the relative positions of the stars."

Yet the actual motions, as compared with terrestrial standards are very rapid. *Arcturus* moves from 200 to 300 miles a second, and the variation in its position can be noted in a few days, such are the refinements of modern instruments. Most of the star-motions are slower than this, ranging "from an imperceptible quantity up to 5, 10, or 20 miles a second."

The star of greatest known proper motion was discovered by KAPTEYN, of Gröningen, in 1897, co-operating with GILL and INNES, of the Cape Observatory. Rapid though its motion is,

"it would require nearly 150,000 years for the star to make a complete circuit of the heavens, if it moved around the Sun uniformly at its present rate."

Groups of stars move together as one system, the *Pleiades* being an example, they having been

"found to move together with such exactness that up to the present time no difference in their proper motion has been detected."

Of motions in the line of sight, or radial motions, Professor NEWCOMB says:—

"No achievement of modern science is more remarkable than the measurement of the velocity with which the stars are moving to or from us."

This result is obtained by the measurement of the minute difference in position of a given line in the spectrum of a moving star, as compared with the position of the same line in the spectrum formed by the same substance rendered incandescent in the tube of the telescope. This method of measurement was put in practice by Sir WILLIAM HUGGINS, and some of the best work is now being done by Professor CAMPBELL at the Lick Observatory with the Mills spectrograph.

A study of the motions of the stars by these methods has led to the discovery of the motion of the solar system, which is stated by Professor NEWCOMB thus:—

"The apex of the solar motion is in the general direction of the constellation *Lyra*, and probably very near the star *Vega*, the brightest of that constellation."

While the data as to the rate of the Sun's motion is meager, only some fifty stars having been observed, yet KAPTEYN

"has derived results which seem to show that the actual velocity of the solar system through space is sixteen kilometers, or ten miles, per second."

VARIABLE STARS.

The fact that some of the stars vary in brightness was known as early as 1596, but it was only in the early part of the nineteenth century that ARGELANDER reduced the study of the variable stars to a system. According to CHANDLER's catalogue, there are 280 of these objects which have been fairly well made out. The "new stars" which blaze out and then fade away are not included in the term "variable stars," but those which go through a regular cycle of change in a definite interval of time. But even in periodic stars, the period is more or less variable.

"The periodic stars show wide differences, both in the length of the period and in the character of the changes they undergo. In most cases they rapidly increase in brightness during a few days or weeks, and then slowly fade away, to go through the same changes again at the end of the period. In other cases they blaze up or fade out, from time to time, like the revolving light of a lighthouse. Some stars are distinguished more especially by their maximum, or period of greatest brightness, while others are more sharply marked by minima, or periods of least brightness. In some cases there are two unequal minima in the course of a period."

Three stars which may be seen by the naked eye illustrate the three general types of variable stars, *o Ceti*, called also *Mira Ceti*, *β Persei*, or *Algol*, and *β Lyræ*.

As to the first, *o Ceti*, its variations are quite irregular. Sometimes, when at its brightest, it rises nearly or quite to the second magnitude. At other times its maximum brightness scarcely exceeds the fifth magnitude. No law has been discovered by which it can be predicted whether it shall attain one degree of brightness or another at maximum. Its minima are also variable. Sometimes it sinks only to the eighth magnitude; at other times to the ninth or lower. As with other stars of this kind, it brightens up more rapidly than it fades away. The period also varies in an irregular way. As to the cause of variation,

"the most plausible view seems to be that changes of a periodic character, involving the irruption of heated matter from the interior of the body to its surface, followed by the cooling of this matter by radiation, are going on in the star."

The star *Algol*, or *β Persei*, is a type of the second class of variables. It is nearly of the second magnitude, but

"at intervals of somewhat less than three days, it fades away to nearly the fourth magnitude for a few hours and then slowly recovers its light.'

The generally accepted explanation of the variation is that the star is double, the companion being dark and of somewhat lesser size than the bright one.

The star *β Lyræ* illustrates the third general class of variables. It varies nearly a degree in brightness, but the rate of variation, unlike *Algol*, is uniform. Its period is thirteen days, but there are two waves of maxima and minima, one maximum being brighter than the other. According to Professor G. W. Meyers, of Indiana,—

"*Beta Lyræ* consists of two bodies, gaseous in their nature, which revolve around each other, so as to be almost touching. They are of unequal size. Both are self-luminous. By their mutual attraction, they are drawn into ellipsoids. The smaller body is darker than the other. When we see the two bodies laterally, they are at their brightest. As they revolve, we see them more and more end on, and thus the light diminishes. At a certain point one begins to cover the other and hide its light. Thus the combined light continues to diminish, until the two bodies move across our line of sight. Then we have a minimum. At one minimum, however, the smaller and darker of the two bodies projected upon the brighter one, and thus diminishes its light. At th other minimum, it is hiding behind the other, and therefore we see th light of the larger one alone."

Variable stars exist having some of the characteristics of eac of these three types, so that no well-defined system of classes ca be established.

THE DISTANCE OF THE STARS.

The distance of the Earth from the stars has always been subject of much interest to mankind. As the stars remain fixe in direction to all ordinary observation, the conclusion has bee drawn that the Earth was fixed in space. The absence of ar swing deceived PTOLEMY, and was advanced as an argume against the Copernican system. Modern instruments and metho have at last detected the swing and measured it. Profess NEWCOMB enters into a detailed explanation of parallax and tl history of the measurements. Several methods of measureme are used, and stars with a large proper motion are general selected. The base line of such a measurement is the diamet of the Earth's orbit; about 184,000,000 miles. Yet with th enormous distance, it is possible to measure the parallax, difference in direction, of but few stars. Some sixty-two hav been measured, and many have been found to be without sensib parallax; in other words, the star seen from the two extremiti of the Earth's orbit, appears to be in exactly the same directio The actual distance is far beyond human conception, but it ma be stated that the star α *Centauri*, with a parallax of nearly o second, is distant from us more than two hundred thousand tim the distance of the Earth from the Sun.

BINARY AND MULTIPLE SYSTEMS.

Sir WILLIAM HERSCHEL was the first to notice that mar stars which to the unaided vision seemed single were really con posed of two stars in close proximity to each other. To the the general term of "double stars" is given. Only those sta which are really double are considered, those which are optical double being of no particular interest. Regarding the numb of such stars, Professor NEWCOMB says:—

"With every increase of telescopic power so many closer and clos pairs are found that we cannot set any limit to the number of stars th may have companions," and "no estimate can be made of the actu number of double stars in the heavens."

"The great interest which attaches to double stars arises from the proof which they afford that the law of gravitation extends to the stars."

Where two stars revolve around a common center of gravity the term "binary system" is applied to them; yet there are systems where three or four stars form a system.

"The times of revolution of the binary systems are so long that there are only about fifty cases in which it has been determined with any certainty."

The shortest period is about eleven years.*

"In the large majority either no motion at all has been detected or t is so slow as to indicate that the period must be several centuries, perlaps several thousand years."

Such a star is *Castor*, or α *Geminorum*. Professor SEE gives wenty-eight periods of less than one hundred years.

SPECTROSCOPIC BINARY SYSTEMS.

In addition to the binary systems discovered by the telescopes, he spectroscope has proved the existence of another class of louble stars, usually termed "spectroscopic binary systems." Of these Professor NEWCOMB says that

"Among the many striking results of recent astronomical research, t would be difficult to name any more epoch-making than the discovery that great numbers of the stars have invisible dark bodies revolving round them of a mass comparable with their own."

The presence of the dark companion is detected by the displacement of the lines of the spectrum of the bright star. In the case of the two stars of a binary system revolving around a center of gravity, the effect produced is as if the bright body alternately advanced and receded. This would result in a displacement of the spectral lines, first to one side and then to the other, of the normal position of the body at rest. The spectroscopic binary systems are very close as regards the distance between the components, and a gap exists between them and the telescopic binary systems, which is being filled as our telescopes increase in power.

"We naturally infer that there is no limit to the proximity of the pairs of stars of such systems, and that innumerable stars may have satellites, planets, or companion stars so close or so faint as to elude our powers of observation."

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*See, however, Professor HUSSEY's orbit of δ *Equulei* in No. 76 of these *Publications*.

STAR CLUSTERS.

Other interesting features of the heavens are the star cl Faint patches of light as seen by the eye are resolved by th scope into masses of bright stars.

"In many cases the central portions of these objects are so con that they cannot be visually resolved into their separate stars, eve the most powerful telescopes." "The most remarkable and sug feature of the principal clusters is the number of variable stars they contain. The richest in variables is *Messier 3*, in which one v has been detected among every seven stars. . . . Very rema at least in the case of ω *Centauri*, is the shortness of the period variables. Out of one hundred and twenty-five found, ninety-eigh periods less than twenty-four hours, . . . the range in brightness two magnitudes."

"Perhaps the most important problem connected with cluster mutual gravitation of their component stars. Where thousands o are condensed into a space so small, what prevents them from all together into one confused mass? Are they really doing so, a they ultimately form a single body? These are questions which satisfactorily answered only by centuries of observation; they therefore, be left to the astronomers of the future."

NEBULÆ.

The nebulæ, which exist in different parts of the sky, another very impressive subject for study. Some few, Great Nebula in *Orion*, may be seen by the naked eye. are of many forms, but in a majority the spiral shape has found. Some are in the form of rings, as the one in Others seem to be scattered in space without form, the neb mass in *Cygnus* being an example. Others have the for discs, and are called "planetary nebulæ."

"It is impossible to estimate the number of nebulæ in the he . . . KEELER estimated the whole number to be several hundred sand . . . A curious fact connected with the distribution of nebul the sky is that it is, in a certain sense, the reverse of the stars. The are vastly more numerous in the regions near the Milky Way and in number near the poles of that belt. But the reverse is the case the nebulæ proper. . . . Perhaps the most obvious suggestion wo that in these two opposite nebulous regions the nebulæ have n condensed into stars. This, however, would be a purely spec explanation."

"The most interesting question connected with these objects of their physical constitution. HUGGINS and SECCHI found pendently that the light of the Great Nebula in *Orion* formed a spe of bright lines, thus showing the object to be gaseous."

"This was soon found to be true of nebulæ in general, that in *Andromeda* being an exception, as it gives a more or less continous spectrum."

"Beyond the general fact that the light of a nebula does not come from solid matter, but from matter of a gaseous or other attenuated form, we have no certain knowledge of the physical constitution of these bodies."

The spectrum of a great number shows a bright line "which loes not correspond to the line of any known substance. The upposed matter which produces it has, therefore, been called *ebulium*." Another conclusion based on their immense dimenions is that they are of extreme tenuity.

MASSES AND DENSITIES OF THE STARS.

Closely connected with the different phenomena to be seen in ie heavens lies the question of the size of the stars.

"The spectroscope shows that, although the constitution of the stars ffers an infinite variety of detail, we may say, in a general way, that iese bodies are suns. It would perhaps be more correct to say that the un is one of the stars and does not differ essentially from them in conitution. The problem of the physical constitution of the Sun and stars iay, therefore, be regarded as the same. Both consist of vast masses f incandescent matter at so exalted a temperature as to shine by their wn light. All may be regarded as bodies of the same general nature. . . In a few cases an approximate estimate of the density of the stars nay be made."

These are binary stars whose parallax or distance from us is cnown.

"But there is a remarkable law which, so far as I know, was first innounced by PICKERING, by virtue of which we can determine a certain relation between the surface brilliancy and the density of a binary system without knowing its parallax."

Here follows a demonstration which space will not permit following, but the conclusion arrived at is that

"the stars in general are not models of our Sun, but have a much smaller mass in proportion to the light they give than our Sun has. They must, therefore, have either a less density or a greater surface brilliancy. . . . Many of them are probably even less dense than air, and in nearly all cases the density is far less than that of any known liquid."

It follows that at least the brighter stars are masses of gas, more or less compressed in their interior by the action of gravitation upon their more superficial parts.

"This conclusion was arrived at, at least in the case of the Sun, from different considerations before the spectroscope had taught us anything of the constitution of the bodies.

SOURCE OF THE SUN'S HEAT.

It is accepted that for untold millions of years, the Sun ha been radiating heat into space, and the problem has been t discover the source of the heat. In the time of KANT, NEW TON, LAPLACE, and HERSCHEL, no reason was known why th stars should not shine on forever without change. Now that he has been determined as a form of energy, the supply of which limited, it becomes a question as to the source of supply. the Sun, composed, as it is known to be, of the same materi as the Earth, kept on radiating its heat as it does without a sour of supply, it would cool off at the rate of from 5° to 10° a yea The theory of meteors falling to the Sun was advanced, but this h been abandoned for the theory of KELVIN and HELMHOLTZ, th the source of the heat is the contraction of the material of t Sun, calculated as 200 feet a year, or four miles in a centur From this it follows that the Sun must be a gas, for

"if solid, the exterior would rapidly cool off, since the heat would have be conducted from the interior. Then, the loss of heat no longer goi on at the same rate, the contraction also would stop and the generati of heat to supply the radiation would cease. Even were the Sun liquid, currents of liquid matter could scarcely convey to the surface sufficient amount of heated matter to supply the enormous radiation."

The fact that the Sun remains gaseous at the extreme densit more than that of water, is explained by the compression of th interior by the weight of the outside portions.

The theory developed by RITTER regarding the source c heat being due to the contraction of the volume of the Sun ha for a basis the paradoxical law announced by LANE, that

"When a spherical mass of incandescent gas contracts through th loss of its heat by radiation into space, its temperature continual becomes higher as long as the gaseous condition is retained."

STELLAR EVOLUTION.

On this is based the theory of stellar evolution. We ma start with the nebulæ, when, by some progressive change, the began to shine. This is the unsolvable question: How did the begin? The gradual contraction under gravity resulted in gaseous body of a higher temperature. It is thus possible t speak of the age of a star, meaning periods measured by tens millions or hundreds of millions of years. Sir WILLIAM HUG GINS gives the series of ages based on the color of light emitte which starting with bluish-white at the first stage, passes on through white into yellow and red. The series is as follows:—

Sirius, α *Lyræ*.	α *Cygni*.
α *Ursæ Majoris*.	*Capella* — The Sun.
α *Virginis*.	*Arcturus*.
α *Aquilæ*.	*Aldebaran*.
Rigel.	α *Orionis*.

A question of interest is, At what stage will the temperature reach its maximum? It is impossible to give a precise answer, but "it seems probable that the highest temperature is reached in about the stage of our Sun."

While the indications point to the truth of this theory,

"Yet there are some unsolved mysteries connected with the case, which might justify a waiting for further evidence, coupled with a certain degree of skepticism."

The nebulæ offer a difficulty. Their extreme tenuity and their seemingly almost immaterial structure appear inadequate to account for any such mutual gravitation of their parts as would result in the generation of the flood of energy they are constantly radiating. We must therefore suggest at least the possibility that all shining heavenly bodies have connected with them some form of energy of which science can, as yet, render no account."

STRUCTURE OF THE STELLAR UNIVERSE.

From the discussion of the origin of the stellar universe, Professor NEWCOMB passes to its structure.

"The problem of the structure and duration of the universe is the most far-reaching with which the mind has to deal. Its solution may be regarded as the ultimate object of stellar astronomy. . . . Although we can attack the problem to-day by scientific methods, to a limited extent, it must be admitted that we have scarcely taken more than the first step toward the actual solution.

"Firstly, we may inquire as to the extent of the universe of stars. Are the latter scattered through infinite space, so that those we see are merely that portion of an infinite collection which happens to be within reach of our telescopes, or are all the stars contained within a certain limited space? In the latter case, have our telescopes yet penetrated to the boundary in any direction?

"Secondly, granting the universe to be finite, what is the arrangement of the stars in space? In what sense, if any, can the stars be said to form a permanent system? Do the stars which form the Milky Way belong to a different system from the other stars, or are the latter a part of one universal system?

"Thirdly, what is the duration of the universe in time? Is it fitted to last forever in its present form, or does it contain within itself the seeds of dissolution? Must it, in the course of time, in we know not how many millions of ages, be transformed into something very different from what it now is?"

The first and third propositions were, according to KANT, equally susceptible of proof or disproof from *à priori* reasoning. The scientific man objects to this conclusion, as the propositions are matters of fact. The more correct view is that of Sir WILLIAM HAMILTON, that the conception of infinite space or time, or the coming to an end of space or time, is impossible for us to hold, the deficiency being due to our mental limitations. So this gives us no clew to the actual universe. Our conclusions must be based on actual observation.

EXTENT OF THE UNIVERSE.

There is a law of optics which throws some light on the question of the extent of the universe. If we assume the stars uniformly distributed throughout space and conceive a number of spherical shells, one outside of another, extended indefinitely, then the number of stars in each spherical shell would be proportional to the square of the radius of the given shell. But the light from the shells varies inversely as the square of the distance from the center where the observer is; therefore each successive shell would send equal amounts of light to the center. In this case if the universe was indefinitely extended, the "heavens would be filled with a blaze of light as bright as the Sun."

"But there are two limitations to this conclusion. It rests upon the hypothesis that light is never lost in its passage to any distance however great. This hypothesis is in accordance with our modern theories of physics, yet it cannot be regarded as an established fact for all space, even if it be true for the distances of the visible stars."

Again, an infinite universe could be imagined on the hypothesis of LAMBERT. A number of groups like the solar form a greater system, and a number of these systems form the Galaxy.

"But modern developments show that there is no scientific basis for this conception, attractive though it is by its grandeur."

"So far as our present light goes, we must conclude that, although we are unable to set absolute bounds to the universe, yet the great mass of stars is included within a limited space, of whose extent we have as yet no evidence. Outside of this space there may be scattered stars or invisible systems. But if these systems exist, they are distinct from our own."

THE ARRANGEMENT OF THE STARS IN SPACE.

"The second question, that of the arrangement of the stars in space, is one on which it is equally difficult to propound a definite general conclusion. . . . Sir WILLIAM HERSCHEL reached the conclusion that our universe was a comparatively thin but widely extended stratum of stars. But we cannot assume that this hypothesis of the form of the universe affords the basis for a satisfactory conception of the arrangement."

The Milky Way would be uniformly illumined, but it is not, being a chain of irregular, cloudlike aggregations of stars. Professor NEWCOMB then enters into a discussion of the appearance of a universe of stars in the form of a circular disc as seen from different directions. Following this is a summary of observed data bearing on the distribution of the stars, the results of which are as follows. The lucid stars increase in density toward the Milky Way, so that if

"the cloudlike forms which make up the Milky Way were invisible to us, we should still be able to mark its course by the condensation of the brighter stars."

Of the fainter stars,—

"the star density in the several regions increases continuously from each pole to the Galaxy itself. . . . The conclusion to be drawn is a fundamental one. The universe, or, at least, the denser portions of it, is really flattened between the galactic poles, as supposed by HERSCHEL and STRUVE."

As to those stars having a proper motion, the following is advanced:—

"Having found that the stars of every magnitude have a tendency to crowd toward the region of the Milky Way, the question arises whether this is true of those stars which have a sensible proper motion. KAPTEYN has examined this question in the case of the Bradley stars. His conclusion is that those having a considerable proper motion, say more than ten seconds per century, are nearly equally distributed over the sky, but that when we include those having a small proper motion, we see a continually increasing tendency to crowd toward the galactic plane. The conclusion is interesting and important. If we should blot out from the sky all the stars having no proper motion large enough to be detected, we should find remaining stars of all magnitudes; but they would be scattered almost uniformly over the sky, and show no tendency toward the Galaxy."

"From this it again follows that the stars belonging to the Galaxy lie farther away than those whose proper motions can be detected."

A study of the heavens will soon show that there is a tendency for the bright lucid stars to form groups, instances of which are the *Pleiades*, *Præsepe*, and *Orion*.

"The question we now propose to consider is whether these clusters include within their limits an important number of the small stars seen in the same direction. If they and all the small stars which they contain within their actual limits were removed from the sky, would important gaps be left? The significance of this question will be readily seen. If important gaps would be left, it would follow that a large proportion of the stars which we see in the direction of the clusters really belong to the latter, and that, therefore, most of the stars would be contained within a limited region."

After a numerical examination of the number of stars within the groups mentioned above, the conclusion is that

"the agglomeration of the lucid stars into clusters does not, in the cases where it is noticeable to the eye, extend to the fainter stars."

A study of the regions relatively poor in lucid stars leads to the same conclusion.

THE MILKY WAY.

Passing now to the structure of the Milky Way, Professor NEWCOMB gives a detailed description of the wonderful object as seen by an observer at different times of the year. One of the first noted facts is the inequalities of structure, which are noticeable to the eye.

"The Milky Way is something more than the result of the general tendency of the stars to increase in number as we approach its central line. There must be large local aggregations of stars, because, as we have already pointed out, there cannot be such diversity of structure shown in a view of a very widely stretched stratum of stars. . . . The fundamental question we meet in our further study of this subject is: At what magnitude do these agglomerations of stars begin? Admitting, as we must, that they are local, are they composed altogether of stars so distant as to be faint, or do they include stars of considerable brightness?"

A method of counting the stars in the regions in question, is followed, and

"The conclusion is that an important fraction of the lucid stars which we see in the same areas with the agglomerations of the Milky Way is really in those agglomerations and forms part of them."

The darker regions of the Milky Way are also found to contain as many stars as there are in the regions immediately on each side of the galactic belt. The evidence is that

"separate from the accumulations of stars in the Milky Way, perhaps extending beyond them, there is a vast collection of scattered stars spread out in the direction of the galactic plane, which fill the celestial spaces in every direction. We have shown that when, from any one area of the sky, we abstract the stars contained in clusters, this great mass is not seriously diminished. We have also collected evidence that the distances of this great mass are very unequal; in other words, there is no great accumulation, in a superficial layer, at some one distance. . . .

ur general conclusion is this: If we remove from the sky all the local ggregations of stars, and also the entire collection which forms the lilky Way, we should have left a scattered collection, constantly increasing in density toward the galactic belt."

Another interesting point to be considered is the increasing umber of stars with diminishing brightness. The number of ars in each succeeding order of magnitude is between three and our times as great as in the preceding one. Using only rough pproximations, the amount of light received will be about oubled for a change of two units of magnitude, the stars of lower agnitude, though fainter individually, being greater in number, ollectively give more light. A careful summary of the star catalogues leads to the general conclusion that

"up to the eleventh magnitude there is no marked falling off in the ratio of increase, even near the poles of the Galaxy."

The question when the series begins to fall away is, therefore, still an undecided one. If there be no diminution of light due to distance, then the number of stars must begin to decrease at some point, or the sky would be filled with a blaze of light.

"From what has been shown of the total amount of light received rom stars of the smaller magnitudes, it would seem certain that a considerable fraction of the apparently smooth and uniform light of the sky nay come from these countless telescopic stars, even perhaps from those which are not found on the most delicate photographs."

The chapter following is devoted to a statistical study of the proper motions of the stars. Space will not permit us to follow Professor NEWCOMB in his argument on this subject. His general conclusion, which he says is in good agreement with that arrived at by Professor KAPTEYN by a different method, is that the average actual motion of a star in space is about 37 kilometers per second. The motion of Sun is given as 20 kilometers. The Sun is therefore a star of quite small proper motion.

DISTRIBUTION OF THE STARS IN SPACE.

In the final chapter, on the distribution of the stars in space, he lines of thought set forth in the former chapters are made to converge on that main and concluding problem. With our system as a center, the celestial space is supposed divided into concentric shells, the radius of the first inside sphere being equal to 206.265 times the orbit of the Earth, or a distance at which the parallax of a star would be 1″. The succeeding shells have radii of 2 R, 3 R, etc., and the parallaxes of the stars on the surface would be respectively 0".5, 0".33, 0".25, etc. In first sphere, since no star has been found with a parallax of the Sun would be alone. Continuing, a list is given of the s whose parallax is known, and the result is that in the sec sphere there would be one star to seven units of space of cube of R. The outer regions give the ratio of one in twel Considering the first result, there would be one star in a sph of radius R, or diameter 412,500 times the Earth's orbit. Lig traveling over 180,000 miles a second would thus pass a st every eight and a half years. A study of the large and sm proper motions leads to about the same conclusion, or one st to eight units of space of the cube of R. By a study of th stars with a cross motion of less than 2".5 per century, it is con cluded that the sphere of lucid stars extends much beyond 400 R

"Granting the star density as we have supposed, a sphere of radiu 400 R would contain 8,000,000 stars. As we see more than this numbe with our telescope, we have no reason to suppose the boundary of th stellar system, if boundary it has, to be anywhere near this limit."

"All the facts we have collected lead to the belief that, out to certain distance, the stars are scattered without any great and wel marked deviation from uniformity. But the phenomena of the Milk Way show that there is a distance at which this ceases to be true. . . Can we form any idea where this difference begins, or what is the neare sphere which will contain an important number of galactic stars? precise idea, no; a vague one, yes. We have seen that the galact agglomerations contain quite a number of lucid stars, and that, perhap an eighth of these stars are outside the sphere 400 R. We may, ther fore, infer that the Milky Way stars lie not immensely outside this spher More than this, it does not seem possible to say at present."

It is probable that we lie near the center of the stellar univers The equality of the stars on both sides of the galactic circle and t fact that the galactic circle is a great circle are offered as proc This merely proves that we lie in the galactic plane. The ev dence as to our lying near the center is not so conclusive, and n until the international photographic survey of the heavens is con pleted does it seem possible to reach a more definite conclusio

Inspired by that spirit of caution which characterizes t entire series of chapters when dealing with conclusions not entire supported by facts, Professor NEWCOMB closes thus:—

"One reflection may occur to the thinking reader as he sees t reasons for deeming our position in the universe to be the central on PTOLEMY showed by evidence, which, from his standpoint, looked sound as that we have cited, that the Earth was fixed in the center of th universe. May we not be the victims of some fallacy, as he was?"

SUN-SPOTS.

By Rose O'Halloran.

Viewed through a four-inch telescope, the surface of the Sun has been as unspotted as untrodden snow for months past.

At length, on the 19th of May, at 11 A.M., a sizable spot in two sections was discerned about twenty degrees inside the northeast limb. In that position some are very distinct, but this had a penumbral aspect, as if the solar atmosphere were very dense. The day following was cloudy; but on the 21st instant, at 9 A.M., in the less foreshortened view, it proved to be a group with three umbræ, one rather large in the foremost section, and two smaller ones in the more easterly section. The adjacent penumbra had commenced to branch northward a few hours afterwards, and on the following morning had developed a distinct umbra, while the two umbræ south of it were transformed into a curving row of five umbræ. On May 23d numerous changes were apparent. The large umbra of the foremost spot was divided, or "bridged," as it is called when a streak of white photospheric matter crosses a dark tract. The new northward umbra of the other section was arching in form, and the last two of the curving row had drifted forward under the three, which in the mean time had united into a dark streak.

The faint penumbral filaments connecting the two divisions had disappeared, and each of the separated tracts had well-defined breaks crosswise where there seemed to be no penumbral matter. The best measurement of position was obtained on the 24th instant, at 11 A.M., as the group was near the center of the disc, and the solar axis corresponded with the meridian. The entire group, which was fully 72,000 miles in length, and elongated in a nearly east-and-west direction, was about eight degrees north of the solar equator.

The foremost umbra was again bridged, the other umbræ were so altered as to form and position as to be scarcely identifiable, and a general shrinkage had evidently set in. On the 25th and 26th instants it was seen only imperfectly through a layer of cloud. On May 27th, 9:45 A.M., the foremost umbra had undergone some changes, as if a part had drifted in advance, and instead of being elongated north and south, it extended in an east-and-west direction. This umbra was in three distinct parts at 11:30 A.M. on May 28th, and the entire formation seemed to be still diminishing.

The general outlines seemed unchanged at 1 P.M. May 29th, but the division in the larger umbra was undiscernible, perhaps on account of the foreshortened view and the solar atmosphere. On May 30th the outlines were still visible near the limbs, but on the 31st it had passed from view. At the present stage of sun-spot minimum the details of a group of more than average size have especial interest, as the known irregularities of the cycle make it possible that they may be the initial footprints of a returning maximum.

SAN FRANCISCO, May 31, 1901.

FLUCTUATIONS OF *NOVA PERSEI.*

BY ROSE O'HALLORAN.

Nova Persei was observed on about fifty clear evenings between 7:30 and 9:00, P. S. T., commencing on February 24th, and ending in the beginning of May. During this period its decline from 1st magnitude to 6.5 was interrupted by nine temporary revivals of light, which were estimated as follows, with the aid of the charts published by Father HAGEN:—

Between February 28th and March 2d, from 2.1 to 1.9 mag.
Between March 11th and 12th, from 3.3 to 3.1 mag.
Between March 20th and 27th one or two fluctuations were noticed, but not having been recorded at the time of observation, the amount of increase or the dates could not be recalled accurately.
Between April 7th and 8th, from 5.2 to 4.6 mag.
Between April 10th and 12th, from 5.4 to 4.6 mag.
Between April 16th and 18th, from 5.6 to 4.2 mag.
Between April 22d and 23d, from 6.5 to 4.0 mag.
Between April 26th and 27th, from 6.0 to 4.5 mag.
Between April 27th and May 6th, from 6.0 to 4.0 mag.

This last estimate of increase was unsatisfactory on account of the interference of high buildings, which hindered further observation afterwards. The intervals in which fluctuations occurred sometimes included cloudy days, so that the dates of increase are those on which the change was first detected at its highest stage. The greatest decline of the *Nova* was to 6.5 magnitude, on the 22d of April.

San Francisco, May 31, 1901.

COMET HOLK.

By Edgar L. Larkin.

The Australian comet, discovered by Holk, April 23d, was well observed at the Mount Lowe Observatory to-night, May 17, 1901, at $7^h\ 38^m$. Its approximate position then was:—

$$\alpha \quad 5^h\ 50^m\ 30^s$$
$$\delta \quad +4^\circ\ 46'$$

The nucleus was small, but bright and distinct in the brilliant twilight, and had the appearance, nearly as could be judged, of a 4th-magnitude, orange-colored star. The tail was about five minutes in length and quite wide. A fog has rested upon the summits of Tujunga and Verdugo Mountains for six days. These ranges constitute the western horizon here, and the comet could not have been seen before. Professor Kreutz's ephemeris was used. The visitor was seen at $7^h\ 38^m$, and disappeared behind the peaks at $8^h\ 13^m$, thus affording only thirty-five minutes for observation. The tail was so faint that it could not be seen in the high power of the micrometer, so it was not measured,— the apparent length being an estimate with low power, 132 Gundlach periscopic. No attempt was made to secure a spectrum, owing to the short time available, and it is doubtful if a spectrum could have been seen in the twilight glow, and still more a subject of doubt whether it would possess value if obtained, owing to vapors round about the mountain tops.

The comet's motion was rapid and could be easily seen in the short time the display was on. There were no catalogue-stars in field. If the comet had been at high altitude, it is probable that the tail would have been as much as one degree in length. The celestial wanderer was almost invisible in the finder, but the nucleus was clearly seen in the 16-inch, while the tail was brighter than thought possible in the glimmer of solar rays and the glow of the Zodiacal Light. And this glowing cone of light is far more brilliant here than at any observatory in the Eastern States.

Altogether the observation seems to have been quite satisfactory under the existing conditions.

Mount Lowe (Cal.) Observatory, May 17, 1901.

PLANETARY PHENOMENA FOR JULY AND AUGUST, 1901.

By Malcolm McNeill.

July.

The Earth is in aphelion July 4, 8 A.M. P. S. T.

Mercury is an evening star at the beginning of the month, too near the Sun to be seen. It rapidly approaches the Sun, passes inferior conjunction on the morning of July 13th, and then rapidly recedes from the Sun. It may be seen as a morning star during the last few days of the month in the early twilight.

Venus is gradually increasing its distance from the Sun, and is beginning to be conspicuous as an evening star. During most of the month it sets rather more than an hour after sunset. It moves about 40° east and 11° south through *Cancer* into *Leo*. On July 28th it passes about 1° north of *Regulus*.

Mars is in the western sky in the evening, setting a little before 10 P.M. at the end of the month. Its rate of recession from the Earth is still over twenty millions of miles per month, and on July 31st its distance from us is about one hundred and sixty-three millions of miles. Its apparent motion among the stars is 16° east and 7° south from *Leo* into *Virgo*. On the evening of July 6th it passes very close, less than 20′, south of the fifth-magnitude star *3 Virginis*.

Jupiter and *Saturn* are still close together in *Sagittarius*, and as they are both near opposition, they are above the horizon practically the entire night. *Jupiter* was in opposition on June 30th, and *Saturn* will be in opposition on July 5th. Both are moving westward, *Jupiter* not quite 4° and *Saturn* rather more than 2°, and at the end of the month are about 7° apart, *Jupiter* being west of *Saturn*.

Uranus is about two hours' motion west of *Saturn*, and sets two hours earlier. It is still in the southern extension of *Ophiuchus*, and moves about 1° westward during the month. There is no bright star near it to mark its position, but at the beginning of the month it is about half a degree north of the sixth-magnitude star *24 Ophiuchi.* Its motion during the month carries it away from the star.

Neptune is a morning star too near the Sun for good observation.

AUGUST.

Mercury is a morning star at the beginning of the month, passing greatest west elongation on the morning of August 2d. It then rises about an hour and a half before sunrise, and the interval is more than an hour until about the middle of the month. After that the planet rapidly approaches the Sun and passes superior conjunction on the afternoon of August 27th.

Venus is an evening star, setting rather more than an hour after sunset throughout the month. It increases its apparent distance from the Sun from 25° to 32°, but at the same time the planet draws more and more south from the Sun, so that the interval between the settings of the Sun and planet remains practically the same. The planet moves 33° east and 15° south during the month, going from *Leo* into *Virgo.*

Mars, at the beginning of the month, is in just about the position *Venus* will occupy at the end. Its rate of recession from the Earth is not quite as great as for two or three months past, being only fourteen millions of miles. On August 31st it is not quite twice the mean distance of the Earth from the Sun distant from us. It has ceased to be a conspicuous object, but will still be about as bright as the standard first-magnitude star. It moves through the constellation *Virgo* 18° east and 7° south. On August 18th it passes about 2° north of the first-magnitude star *Spica, α Virginis.* Its brightness will then differ little from that of the star, but its ruddy color will make it readily distinguishable.

Jupiter and *Saturn* still keep their positions in *Sagittarius* north of the group called the "Little Dipper." They are setting earlier, and by the end of the month do not remain above the horizon much after midnight. They still keep up their retrograde motion toward the west, but more slowly than before; and *Jupiter* becomes stationary just before the end of the month, while *Saturn* does not reach his turning-point until a fortnight later. Their distance apart remains pretty constantly a little more than 7°, and each moves about a degree and a half westward among the stars.

Uranus sets about two hours earlier than during July. It retrogrades slowly until August 22d, when it becomes stationary, and then begins its eastward motion.

Neptune is a morning star, but by the end of the month rises a little after midnight.

Look out for meteors during the middle of the month, more especially the nights from August 11th to 13th. This shower, which comes yearly, radiates from the constellation *Perseus*. This rises in the northeast in the early evenings. More meteors are likely to be seen after midnight than before.

July–August, 1901.

Phases of the Moon, P. S. T.

Full Moon . . .	July	1,	3^h 18^m	P. M.
Last Quarter . . .	July	8,	7 20	
New Moon . . .	July	15,	2 10	A. M.
First Quarter . . .	July	23,	5 58	
Full Moon . . .	July	31,	2 34	
Last Quarter . . .	Aug.	7,	12 2	
New Moon . . .	Aug.	14,	12 27	
First Quarter . . .	Aug.	21,	11 52	P. M.
Full Moon . . .	Aug.	29,	12 21	

The Sun.

1901.		R. A.	Declination.	Rises.	Transits.	Sets.
July	1,	6^h 39^m	+ 23° 9′	4^h 39^m A. M.	12^h 3^m P. M.	7^h 27^m P. M.
	11,	7 20	+ 22 11	4 46	12 5	7 26
	21,	8 0	+ 20 34	4 53	12 6	7 19
Aug.	1,	8 44	+ 18 9	5 3	12 6	7 9
	11,	9 22	+ 15 25	5 11	12 5	6 59
	21,	10 0	+ 12 17	5 21	12 3	6 45
	31,	10 36	+ 8 49	5 30	noon	6 30

Mercury.

July	1,	7 50	+ 18 25	6 9 A. M.	1 14 P. M.	8 19 P. M.
	11,	7 31	+ 17 6	5 17	12 16	7 15
	21,	7 10	+ 18 0	4 12	11 15 A. M.	6 18
Aug.	1,	7 22	+ 20 3	3 34	10 45	5 56
	11,	8 18	+ 20 3	3 50	11 1	6 12
	21,	9 36	+ 16 2	4 44	11 40	6 36
	31,	10 52	+ 9 0	5 45	12 16 P. M.	6 47

Venus.

901.	R. A.	Declination.	Rises.	Transits.	Sets.
r 1,	7 51	+22 22	5 54 A.M.	1 15 P.M.	8 36 P.M.
11,	8 42	+19 49	6 17	1 27	8 37
21,	9 31	+16 20	6 40	1 37	8 34
g. 1,	10 23	+11 42	7 6	1 46	8 26
11,	11 8	+ 6 56	7 27	1 51	8 15
21,	11 53	+ 1 53	7 49	1 56	8 3
31,	12 36	— 3 17	8 11	2 0	7 49

Mars.

r 1,	11 36	+ 3 15	10 48 A.M.	5 0 P.M.	11 12 P.M
11,	11 56	+ 0 54	10 38	4 41	10 44
21,	12 17	— 1 32	10 27	4 22	10 17
. 1,	12 40	— 4 15	10 16	4 2	9 48
11,	13 3	— 6 46	10 8	3 45	9 22
21,	13 26	— 9 16	10 1	3 29	8 57
31,	13 51	—11 44	9 54	3 14	8 34

Jupiter.

1,	18 35	—23 10	7 26 P.M.	12 2 A.M.	4 38 A.M.
. 1,	18 20	—23 25	5 5	9 40 P.M.	2 15
t. 1,	18 14	—23 31	2 59	7 33	12 7

Saturn.

1,	18 58	—22 18	7 45 P.M.	12 25 A.M.	5 5 A.M
g. 1,	18 49	—22 33	5 30	10 9 P.M.	2 48
t. 1,	18 43	—22 43	3 24	8 2	12 40

Uranus.

y 1,	16 50	— 22 30	5 35 P.M.	10 14 P.M.	2 53 A.M
g. 1,	16 47	— 22 24	3 29	8 8	12 47
pt. 1,	16 46	— 22 23	1 26	6 5	10 44

Neptune.

y 1,	5 57	+22 18	4 2 A.M.	11 22 A.M.	6 42 P.M.
g. 1,	6 2	+22 18	2 4	9 24	4 44
pt. 1,	6 5	+22 17	12 6	7 26	2 46

Eclipses of *Jupiter's* Satellites, P. S. T.

(Off right-hand limb as seen in an inverting telescope.)

II, R,	July	2,	9^h	13^m	P.M.	II, R,	Aug.	3,	8^h	57^m	P
I, R,		5,	2	37	A.M.	III, D,		4,	9	37	
I, R,		6,	9	6	P.M.	III, R;		5,	12	37	A
IV, R,		7,	12	51	A.M.	I, R,		5,	11	13	P
II, R,		9,	11	49	P.M.	I, R,		7,	5	42	
I, R,		12,	4	32	A.M.	II, R,		10,	11	34	
I, R,		13,	11	0	P.M.	III, D,		12,	1	37	A
I, R,		15,	5	29		I, R,		13,	1	8	
II, R,		17,	2	25	A.M.	I, R,		14,	7	37	P.
I, R,		21,	12	55		I, R,		21,	9	32	
I, R,		22,	7	24	P.M.	I, R,		23,	4	0	
IV, D,		23,	4	38		II, R,		28,	6	8	
IV, R,		23,	7	3		I, R,		28,	11	27	
II, R,		27,	6	20		I, R,		30,	5	55	
III, R,		28,	8	36							
I, R,		29,	9	18							

'ICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

MAGNITUDE ESTIMATES OF *NOVA PERSEI.*

ates of the brightness of the new star in *Perseus* have le as regularly as possible since February 24th, when ts discovery was received.

estimates at first were made without any instrumental omparing the star with *Capella* α, ε, δ, ν, κ *Persei.* As light faded, opera-glasses, and later the 3-inch finder 2-inch telescope, and still later the 12-inch telescope re used, comparisons being made with the stars ψ, σ, and with BD + 43°.674, BD + 45°.778, BD + 44°.734; iitudes of the comparison stars being taken from Chart I.

bservations show that the light of the *Nova*, while it has ng, has been subject to marked fluctuations almost from ning — a fact that is abundantly confirmed by observers :. But no definite period of variation can be satisfac- ablished from the. observations made here, nor yet ning with them those made at other places so far as these n published.

ollowing table gives the magnitudes of the new star rom my observations:—

	P. S. T. h	m	1901	P. S. T. h	m
. . .	8	0.5	Mar. 12	9	3:5
. . .	1	1.0	13	9	3:7
. . .	6:30	0.9	14	7—10	3:5
. . .	7:30	1.4	15	8	3:8
. . .	7	2.0	16	8	3:9
. . .	10	2.0	17	8—10	3:9
. . .	8	2:4	18	8	4.0
. . .	7	2:4	19	7—9	4.1
. . .	7	2:5	20	7:30	4.5
. . .	8:20	2:5	22	8	4.7
. . .	7—10	2:7	23	7	4.0
. . .	7—10	3:0	28	8	4.7
. . .	7	3:2	28	10	5.0

stronomical Department of the University of California.

1901	P. S. T. h	m	1901	P. S. T. h	m
Mar. 29	9	5.0	Apr. 23	7:30—9:30	4.5
31	9	4.7	25	8	5.3
Apr. 1	9:30	4.5	26	8:30—9	5.4
4	7:30	4.2	May 2	8:45	4.7
5	8	4.7	3	8:15	5.4
6	8	5.0	4	8:30	6.0
7	8	5.4	5	8	6.0
8	9	4.2	6	8	5.8
9	8	5.0	7	8	4.4
10	9	5.5	8	8	5.3
11	8—10	5.7	9	8	5.8
13	7:30	6.0	10	8	6.0
14	8	6.1	11	7:50	6.0
15	8	6.1—6.2	12	8:30	5.7
16	8	6.0—6.1	13	8:15	5.5
17	7:30	4.4	14	8.20	5.7
19	8	5.5	15	8:25	6.0
20	8	6.2	16	8	5.8
21	8	5.6	17	7:50	4.7—4.8
22	8:30	4.7	19	8	6.0—6.2

May 22, 1901. R. G. AITKEN.

NOTE ON COMET *a* 1901.

This comet was discovered independently at several stations in the southern hemisphere, and for a time was to southern observers a conspicuous object in the morning and later on in the evening sky.

Because of its position south of the Sun, it could not be seen at northern observatories during its period of greatest brightness. It was looked for here carefully on every clear evening and morning from April 26th, the date of the announcement of its discovery, until May 3d, when the cablegram from Arequipa showed that it had passed the Sun and become an evening object. The evening sky was then searched without success until Tuesday, May 14th, when in the strong twilight it was seen as a hazy star of about the eighth magnitude in R. A. $5^h\ 33^m$; Decl. $+3° 34'$. This seems to have been the first observation made of the comet in the northern hemisphere.

Accurate observations secured on the evenings of May 15th and 16th, showed that it was a little behind the position predicted by Dr. KREUTZ's preliminary orbit, and that it was fading quite rapidly. On the latter date two stars, called 8.2 and 8.7 magnitude respectively in the Albany A. G. Catalogue, were in the telescope-field with the comet; the one was certainly brighter, the other fainter, than the comet. Last night, May 21st, it was fainter than a star of ninth magnitude,— too faint for accurate measures in the twilight and haze. R. G. AITKEN.

May 22, 1901.

Measures of δ *Equulei*, = OΣ 535.

Unfavorable weather prevented observations of this interesting binary until the morning of May 3d (astronomical date). It was then distinctly elongated, and a measure was secured without much difficulty. Another measure was made on the following morning under somewhat less favorable conditions, though the elongation was unmistakable. The distance measured in a pair of this kind is likely to be the longer diameter of the image, rather than the actual distance between the centers of the two components, unless the observing conditions are ideal. My estimates of distance on both nights, based on the thickness of the micrometer wires, was $\frac{1}{10}''$ or a very little more.

The measures are:

	θ	ρ	wt.
1901.337	201°.5	0″.13	4.
1901.340	200 .3	0 .16	3.

The quadrant is wholly indeterminate. I have taken the third quadrant for the purpose of comparison with Professor Hussey's ephemeris (No. 76, p. 223, these *Publications*), which gives for 1901.338 192°.0 0″.10.

R. G. Aitken.

Measures of the Companions to *Sirius* and *Procyon*.

Sirius.

1901.165	135°.7	4″.97	3	36
.277	134 .4	5 .18	4	36
.296	135 .0	5 .25	4	36
1901.25	135°.0	5″.13		

Procyon.

1901.154	337°.1	″	3	36
.156	338 .6	5 .23	3	36
.299	339 .9	5 .05	3	36
1901.20	338°.5	5″.13		

The last two measures of *Sirius* were made in strong twilight. The seeing then was excellent, so that a thousand-power eyepiece could be used and the companion could be seen steadily during the whole time of observation. The good seeing lasted only a short time, however, and *Procyon* could not be measured on either night. The companion to the latter star is now much harder to see than the companion to *Sirius*, and the measures, especially of distance, are subject to much larger probable error.

ZWIERS's ephemeris gives for *Sirius*:—

1901.25 133°.3 5″.07.

R. G. AITKEN.

May 8, 1901.

THE DEATH OF PROFESSOR ROWLAND.

The physical side of Astronomy suffered a great loss on April 16th, in the death of Professor HENRY A. ROWLAND, of Johns Hopkins University, in the fifty-third year of his age. Professor ROWLAND occupied the Chair of Physics from 1876, the date of the opening of the university, until the time of his death.

Professor ROWLAND'S contributions to our knowledge of heat, electricity, and light earned for him a place in the front rank of the physicists of the world. Astronomy is indebted to him mainly for the perfection of the diffraction-grating and for his studies on the grating spectrum of the Sun. His tables of wave-lengths in the solar spectrum are so generally in use that they may be said to form the basis of all accurate astronomical spectroscopy. His premature death has given rise to heartfelt expressions of regret from the entire scientific world.

W. W. C.

THE LICK OBSERVATORY BULLETIN.

Early in the present year the Lick Observatory began to issue a bulletin to supply a want long felt. Its purpose was to furnish a medium of publication insuring prompt distribution of important results, and likewise that it should be used for publishing long and technical articles unsuitable for journal publication, and which could not await publication in volume form.

It is not intended that the mailing-list shall include individuals except in the rare cases where investigators have not ready access to the *Bulletin* through institutions.

Bulletins Nos. 1 and No. 2 have been issued. They contain Professor TUCKER'S meridian-circle positions of the comparison-stars to be used as a basis for determining the solar parallax, from observations of the planet *Eros*. The total number of stars observed by Professor TUCKER is 677. The total number of observations required was slightly over 2,000, including circumpolars and nadirs.

The materials for a number of other Bulletins are at hand, and they will be issued in the near future. W. W. CAMPBELL.

VISUAL OBSERVATIONS OF *NOVA AURIGÆ.*

It is stated in the *Observatory* for March, 1901, (p. 127,) that ANDERSON'S new star of 1892 in *Auriga* "has not been seen for many years"; a statement perhaps implying, from its context, that *Nova Auriga* has been invisible.

This star was looked for by Mr. AITKEN and myself with the 36-inch refractor on the evening of April 4, 1901, and was found without difficulty, though the sky was hazy and strongly illumined by the full moon. The *Nova* was fainter by 0.2 magnitude than BURNHAM'S comparison-star I (chart in *Mon. Not.*, R. A. S. for April, 1892,) and considerably brighter than comparison-star J. Its magnitude was estimated to lie at one fourth the distance from that of I to that of J. That is, the *Nova* was estimated to be of the 12th magnitude on BURNHAM'S scale.

The same peculiarities of focus existed as in previous years; and no doubt the spectrum is still nebular. No opportunity was available for making direct spectroscopic observations.

My last previous observation was in August, 1898, when *Nova Auriga* was of the 11th magnitude.

The brightness of the *Nova* at its second discovery, in August, 1892, was 10.5 magnitude. W. W. CAMPBELL.

THE CROCKER ECLIPSE EXPEDITION TO SUMATRA.

The Crocker Eclipse Expedition from the Lick Observatory to Sumatra, in charge of Acting Astronomer C. D. PERRINE, arrived at Padang on April 5th, with the instruments and other freight in good condition. After a preliminary survey of the surrounding country, Professor PERRINE decided to locate the observing-station on the plains rather than in the mountains, as, from his own observations and from the experience of scientific residents of Padang, the cloud conditions were considered more favorable at the lower altitudes. The station was located just outside the northern edge of the city, on the abandoned racetrack. Preparations for mounting and adjusting the instruments were proceeded with rapidly, and volunteer observers were arranged for shortly after the arrival of the party. No doubt Professor PERRINE had the instruments in complete preparation and the assistants thoroughly drilled by the time of the eclipse.

A cablegram received at the Lick Observatory on May 18th stated that at the time of totality considerable interference from clouds was experienced; but the hope was expressed that useful results had been obtained. A later cablegram, on May 24th, presumably after the photographic plates had been developed, contained the gratifying information that some results had been obtained with all the instruments. No doubt the exposures of the photographic plates were madc according to programme; and the natural interpretation of the two cablegrams is that the successful photographs were obtained in the intervals between clouds floating over the Sun.

Further information concerning the details of the results is not expected until about July 10th, when Professor PERRINE'S letters will probably arrive.

Inasmuch as this eclipse was of unusually long duration, it is hoped that the results will compare in quantity and quality very favorably with those secured at the eclipses of short duration in 1898 and 1900.

W. W. CAMPBELL.

ASTRONOMICAL TELEGRAMS.

(Translations.)

CAMBRIDGE, MASS., Apr. 26, 1901.

To Lick Observatory: (Received 1:00 P.M.)

Kiel cables that a very bright comet was discovered by HALLS at Queenstown, April 23; it was observed at the Cape of Good Hope on April 24.712 Greenwich M. T. in R.A. $1^h\ 30^m\ 4^s$; Declination $+3°\ 27'$; approximate observation, sent by GILL.

(Signed) EDWARD C. PICKERING.

BOSTON, Mass., May 3, 1901.

To Lick Observatory: (Received 1:40 P.M.)

Arequipa cables a very bright comet seen in R. A. $3^h\ 30^m$; Declination south 1°. Probably Thursday morning.

(Signed) JOHN RITCHIE, JR.

[A letter received later from Harvard College Observatory indicates that the comet was seen at Arequipa on the evening of Thursday, May 2, at $11^h\ 35^m$ G. M. T.]

CAMBRIDGE, MASS., May 7, 1901.

To Lick Observatory: (Received 11:40 A.M.)

Kiel cables that the bright comet discovered in the South will appear in the Northern Hemisphere. It was observed at the Cape of Good Hope on May 3.2115 G. M. T. in R. A. $3^h\ 40^m\ 32^s.4$; Decl. $-0^\circ\ 31'\ 49''$; and on May 4.2187 G. M. T. in R. A. $3^h\ 54^m\ 29^s.2$; Decl. $-0^\circ\ 18'\ 27''$. The comet is circular, less than $1'$ in diameter, brighter than third magnitude, with well-defined nucleus, and tail longer than 2°.

(Signed) E. C. PICKERING.

CAMBRIDGE, MASS., May 10, 1901.

To Lick Observatory:

Kiel cables that elements and ephemeris of Comet *a* 1901 were computed by KREUTZ, from the observations of April 24, May 3, and May 4, as follows:

$$
\begin{aligned}
T &= \text{April } 24.22 \text{ G. M. T.} \\
\omega &= 202^\circ\ 50' \\
\Omega &= 109\ \ 57 \\
i &= 131\ \ 26 \\
\text{nat. } q &= 0.2446
\end{aligned}
\quad \left.\begin{matrix} \\ \\ \\ \end{matrix}\right\} \text{Ecliptic and mean Equinox for 1901.0.}
$$

(Signed) E. C. PICKERING.

[The ephemeris is here omitted.]

LICK OBSERVATORY, Mt. Hamilton, Cal., May 15, 1901.

To Harvard College Observatory, Cambridge, Mass.: (Sent 10:15 P.M.)

The comet discovered at Queenstown was observed by AITKEN on May 15.6668 G. M. T. in R. A. $5^h\ 38^m\ 25^s.8$; Decl. $+3^\circ\ 52'\ 12''$. (Signed) R. H. TUCKER, in charge.

CAMBRIDGE, MASS., May 8, 1901.

To Lick Observatory: (Received 12:50 P.M.)

The variation in the light of *Eros*, WENDELL, observer, is now zero. (Signed) E. C. PICKERING.

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in carrying out the work of this department. Communications of general interest will be gladly received, and may be sent to SIDNEY D. TOWNLEY, 2023 Bancroft Way, Berkeley, California.

The appearance of the new star in the constellation *Perseus* aroused considerable interest in the astronomical world, such objects being rare in the history of astronomy. According to an article in *The Observatory* for March, there are only about a score on record, as the following list, taken from Miss CLERKE'S "System of the Stars" will show. The date of the discovery and the constellation in which they appeared are given:—

B. C. 134.	*Scorpio.*	827.	*Scorpio.*	1670.	*Vulpecula*
A. D. 123.	*Ophiuchus.*	1012.	*Aries.*	1848.	*Ophiuchus.*
173.	*Centaurus.*	1203.	*Scorpio.*	1860.	*Scorpio.*
386.	*Sagittarius.*	1230.	*Ophiuchus.*	1866.	*Corona.*
389.	*Aquila.*	1572.	*Cassiopeia.*	1876.	*Cygnus.*
393.	*Scorpio.*	1604.	*Ophiuchus.*	1885.	*Andromeda.*

To these must be added the *Novæ*, in *Auriga*, 1892, in *Norma*, 1893; in *Carina*, 1895; in *Centaurus*, 1895; in *Sagittarius*, 1898; and in *Aquila*, 1899; the four from 1893 to 1898 having been discovered photographically by the Harvard observers. The fact that the later years have witnessed the discovery of a greater number of such stars is but a natural result of the greater number of observers and the fact that in earlier times only the brighter *Novæ* were observed and recorded.

To find a parallel to the present case of *Nova Persei*, it is necessary to go back to the year 1604, when the star known as KEPLER'S, but discovered by BRUNOWSKI, appeared as bright as *Jupiter*. TYCHO'S star, in 1572, was first seen as bright as *Jupiter* and increased quickly, so that it became equal to *Venus;* the star in 1203 is said to have been equal to *Saturn*, and others in the list were equally conspicuous. The appearance of these was, in general, very sudden. It is of interest to note that all of these stars with the exception of the stars of 1012 and 1866 lay in or close to the Milky Way. The star of 1860 appeared suddenly as a 7th-magnitude star in the middle of a nebula or close cluster (Dreyer 6093), and the star in *Andromeda* was seen by Dr. HARTWIG on August 31, 1885, as a nucleus to the well-known nebula.

Sir WILLIAM HUGGINS pronounced the spectrum of *T Coronæ* to be due to glowing hydrogen, as though it were a sun like our own, with very exaggerated prominences. The star *Nova Cygni*, as seen by VOGEL, had at first a spectrum nearly continuous, crossed by bright lines due to hydrogen, and by others due to unknown substances, but finally became similar to the spectrum of a nebula.

The spectrum of the *Nova* in *Auriga* was crossed by bright lines due to hydrogen and other elements, but also by dark lines due to the same elements, the bright and dark lines being displaced relatively to each other. This was interpreted by Professor LOCKYER and others as an evidence of relative motion of two bodies; and from this it was assumed that two bodies had collided and that the outburst of heat was caused by the loss of kinetic energy. This is held by Professor LOCKYER to be true of *Nova Persei.* Another supposition of equal weight would be that the spectrum was that of a body of the solar type from which hydrogen gas was emanating with the velocity shown by the displacement of the lines, some 700 miles a second, which is not an inconceivable velocity. This latter supposition is, however, lacking in the fact that it does not assign a cause for the sudden outburst, as the collision theory does.

The article concludes with a statement of the present status of these variable stars. The star of KEPLER and the nucleus in the nebula of *Andromeda*, as well as *Nova Aurigæ*,* have disappeared, *T Coronæ* has resumed the condition it was in before 1866. *Nova Cygni* was seen as a 15th-magnitude star in 1885, and probably remains so at present. There is reason for thinking that *Nova Cygni* of 1670, which lasted as a bright star until 1672, was identical with the 11th-magnitude star found by Mr. HIND in 1852.

The variability of the light of the planet *Eros*, noted in the last issue of the *Publications*, has been investigated by M. ANDRÉ, of Lyons, who has determined its period and advanced an explanation for the variation. Combining his own results with those of Herr DEICHMUELLER at Bonn, M. ANDRÉ announced that the variation had a period of $5^h\ 16^m$, and consisted of two waves. The second wave is shorter than the first by twenty-five minutes, although this is open to some question. Other observers

* See Professor CAMPBELL'S note in Notices from Lick Observatory.

had also noted the variation in light, but had fixed the period at 2^h $37^m.6$, or nearly one-half of the double period given by M. ANDRÉ.

The light curve is almost precisely similar to those of *B Lyræ* and *U Pegasi*, the variation of light being continuous without any flat portion to the curve, as in stars of the *Algol* type. The variation is at least a magnitude, some observers making it as much as 1.5 or 2 magnitudes.

M. ANDRÉ offers as an explanation of the variation the supposition that the planet is double, the two minima being caused by the occultation of one of the pair by the other. He gives the elements of the system, the semi-major axis of relative orbit being but slightly greater than the sum of radii. The dimensions of the two bodies are as 3 to 2, with a mean density of the system of 2.4.

At Toulouse, M. L. MONTANGERAUD allowed the planet to trail on the plate, and the maxima and minima could thus be located. The period obtained was 2^h 38^m, which is exactly one-half of that given by M. ANDRÉ.

Mr. CROMMELIN, in commenting in *The Observatory* on the theory advanced by M. ANDRÉ, says: "It is scarcely necessary to say that this hypothesis is only given provisionally and as affording a possible explanation of the light curve. The idea of a double minor planet is an utterly unexpected one, and one that does not at first sight commend itself as at all probable. But if we once admit the initial fact that *Eros* in February was subject to variations of light considerably exceeding a magnitude,— a fact for which the evidence is certainly strong,— we seem almost driven to some such hypothesis as that of M. ANDRÉ."

A note in the *Monthly Notices* of the Royal Astronomical Society for February, 1901, summarizes the report of M. BOUQUET upon the visual observations of the ten expeditions sent out by the French Academy of Sciences to observe the transit of *Venus* in 1882. The results of M. BOUQUET appeared in *Comptes Rendus* in 1899. The ten different expeditions occupied stations in North and South America, separated by 85° of latitude, while the most eastern were distant but 3° of longitude from the most western. The best determination of the solar parallax was therefore to be determined by HALLEY'S method from observations of second and third contact. The final result, as arrived at by M. BOUQUET, was 8".80 for the solar parallax.

In the same issue of the *Monthly Notices* a review is given of Volume VIII, Part 2, of the "Annals of the Royal Observatory Cape of Good Hope," in which Dr. DAVID GILL publishes the results of his observations of stellar parallax in the Southern Hemisphere made since 1887.

The resulting stellar parallaxes published in this volume are:—

Star.	Mag.	Parallax.	Prob. Error.
Sirius	—1. 8	0".370	±0".010
Canopus	—1. 0	0 .000	±0 .010
Rigel.........	0.35	0 .000	±0 .010
Achernar	0. 5	0 .043	±0 .015
β *Centauri*	0. 8	0 .046	±0 .017
α *Crucis*	1. 0	0 .050	±0 .019
Spica	1. 2	—0 .019	±0 .010
Formalhaut ...	1. 3	0 .130	±0 .014
α *Scorpii*......	1. 3	0 .021	±0 .012
β *Crucis*	1. 5	0 .000	±0 .008
α *Gruis*	1. 9	0 .015	±0 .007
β *Hydri*	2. 9	0 .134	±0 .007
τ *Ceti*	3. 6	0 .310	±0 .012
Lacaille 2957..	6. 0	0 .064	±0 .024
P XIV 212 ...	{ A 6. 3 B 7. 9	0 .167	±0 .008
Z. C. V. 243 ..	8. 5	0 .312	±0 .016

A TEXT-BOOK OF ASTRONOMY. By GEORGE C. COMSTOCK, Director of the Washburn Observatory and Professor of Astronomy in the University of Wisconsin. D. Appleton and Company, New York. 391 pages. Cloth. $1.30.

Written in simple, clear, and concise language, illustrated by appropriate and well-constructed figures, made interesting by apt and homely comparisons and useful by numerous and well-chosen exercises, this book forms a welcome addition to the list of elementary text-books of astronomy. Professor COMSTOCK has written a new book, and has not merely rearranged the material of earlier ones. His purpose is clearly outlined in the first paragraph of the preface:—

"The present work is not a compendium of astronomy or an outline of popular reading in that science. It has been prepared as a text-book, and the author has purposely omitted from it much matter interesting as well as important to a complete view of the science, and has endeavored

to concentrate attention upon those parts of the subject that possess special educational value. From this point of view matter which permits of experimental treatment with simple apparatus is of peculiar value and is given a prominence in the text beyond its just due in a well-balanced exposition of the elements of astronomy, while topics, such as the results of spectrum analysis, which depend upon elaborate apparatus, are in the experimental part of the work accorded much less space than their intrinsic importance would justify."

Inspection of the table of contents shows that the author has departed widely from the conventional methods of treating the elements of the subject, especially in the first six and the eighth chapters. The special features of the book are numerous questions scattered throughout the text, to teach the student to think and construct as well as to read and assimilate; and many exercises, in the nature of laboratory work, all to be performed with simple apparatus, easily constructed by the students themselves. In these exercises the students obtain practice in the three fundamental processes of all practical astronomy, the measurement of time, angle, and distance. Although the exercises are numerous, still the author has not exhausted the list, and might with profit have given more.

It would have been well, if possible, to so arrange the material that the exercises, which all fall in the first five chapters, would be more distributed. It is not necessary, of course, that the teacher present the material in just the order given; but the facts are that the large majority of teachers will present it in that way. The author has, apparently, purposely avoided all reference to the Nautical Almanac and American Ephemeris. The wisdom of this is open to question. While it is unnecessary and certainly unwise to introduce the Ephemeris at first, and thus make the student dependent upon it, still I think it equally unwise to totally exclude it. An explanation of the Ephemeris and a few exercises which demand its use should, I think, be included in the most elementary course in practical astronomy. Any school in which astronomy is taught can surely afford to buy one of these books each year, and any person capable of teaching the subject should be able to use the book intelligently.

Many bits of good advice are given in connection with the exercises. On page 3, for instance, in connection with a measurement to be made, we find, "but perfection can seldom be attained, and one of the first lessons to be learned in any science which deals with measurement is, that however careful we may be in our work, some minute error will cling to it, and our results can be only approximately true. This, however, should not be taken as an excuse for careless work, but rather as a stimulus to extra effort in order that the unavoidable errors may be made as small as possible."

A point to be commended is the use of the metric system throughout the exercises. In the descriptive parts of the text, however, the author retains the English units. Perhaps it is best to break away gradually, but I believe no criticism would have been offered if the metric system had been used throughout.

The illustrations and figures of the book are well chosen, and the student should learn something from each. Very few, if any, have been inserted for pictorial effect. Among the figures which deserve special mention are numbers 16 and 17 from which the position of any of the five brighter planets may be determined for a number of years; number 23, which ingeniously illustrates the tide-raising forces; number 54, illustrating the Moon's rotation; number 121, illustrating the determination of the parallax of the fixed stars.

Of the many apt illustrations contained in the book, the following (page 121) is one of the best:—

"Every such timepiece, whether it be of the nutmeg variety which sells for a dollar, or whether it be the standard clock of a great national observatory, is made up of the same essential parts, which fall naturally into four classes, which we may compare with the departments of a well-ordered factory: I. A time-keeping department, the pendulum or balance-spring, whose oscillations must all be of equal duration. II. A power department, the weights or mainspring, which, when wound, store up the power applied from outside and give it out piecemeal as required to keep the first department running. III. A publication department, the dial and hands, which give out the time furnished by department I. IV. A transportation department, the wheels which connect the other three and serve as a means of transmitting power and time from one to the other. The case of either clock or watch is merely the roof which shelters it and forms no department of its industry. Of these departments the first is by far the most important, and its good or bad performance makes or mars the credit of the clock."

On page 209, in speaking of the law of the Sun's rotation as "very peculiar and extraordinary," the author gives a new lease of life to a long-standing misconception. Is there anything peculiar or extraordinary in the fact that the particles of a gaseous body move differently under the forces of rotation than do the particles of a solid body? Would it not rather be peculiar and extraordinary if a gaseous body did rotate in the same way as a solid one? A few years ago Dr. WILCZYNSKI, in "Hydrodynamische Untersuchungen mit Anwendungen auf die Theorie der Sonnenrotation," showed that the law of the Sun's rotation was only one of an infinite number of ways in which a gaseous body might rotate.

The last chapter, "Growth and Decay," deserves special mention. It is a conservative philosophic exposition of the best theories of solar and sidereal evolution, and although not out of place in a high-school text, it might well form a part of a larger treatise.

The work of the publishers has been most excellently done, and the book, as a whole is, I think, the best elementary astronomy yet published. S. D. T.

The Directors of the Benjamin Apthorp Gould Fund announce that the following grants have been made: To Mr. JOHN A. PARKHURST, $30; to Dr. HERMAN S. DAVIS, $500; to Mr. PAUL S. YENDELL, $225; to Professor SIMON NEWCOMB, $25. A considerable additional amount of income has accrued, for the distribution of which applications are awaited. In addition to the above call for applications the Directors, desiring to stimulate the participation of American astronomers in the attempt to bring up the arrears of cometary research, offer to them the sum of $500 for computation of the definitive orbits of comets (see list in *A. J.*, 493, p. 104); this sum to be distributed at the average rate of $100 for each computation,— the amount to vary according to the relative difficulty of the computation, and to be determined by the Directors of the Gould Fund. Computers should promptly notify the Directors (Professors LEWIS BOSS and ASAPH HALL and Dr. S. C. CHANDLER) of their participation or desire to participate, and manuscripts should be submitted not much later than July 1, 1902.

The degree of Doctor of Philosophy was recently conferred by the University of California upon two students of astronomy. Mr. R. T. CRAWFORD, for three years Fellow at the Lick Observatory, presented Astronomy as his major subject, and Mathematics and Physics as his minors. His thesis was entitled, "Determination of the Constant of Refraction from Observations made with the Repsold Meridian-Circle of the Lick Observaory." Mr. F. E. Ross, Fellow at the Lick Observatory in 1898–'99, presented Mathematics as his major, and Astronomy and Physics as his minors. His thesis was "On Differential Equations belonging to a Ternary Linearoid Group."

The meeting of the Board of Directors of the Astronomical Society of the Pacific, and the meeting of the Society itself, which were to be held at the Lick Observatory on June 8th, were adjourned, without transacting business, for lack of a quorum.

OFFICERS OF THE SOCIETY.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.
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410
9

PUBLICATIONS

OF THE

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OF THE PACIFIC.

VOLUME XIII.

NUMBER 80.

1901.

SAN FRANCISCO:

PRINTED FOR THE SOCIETY.

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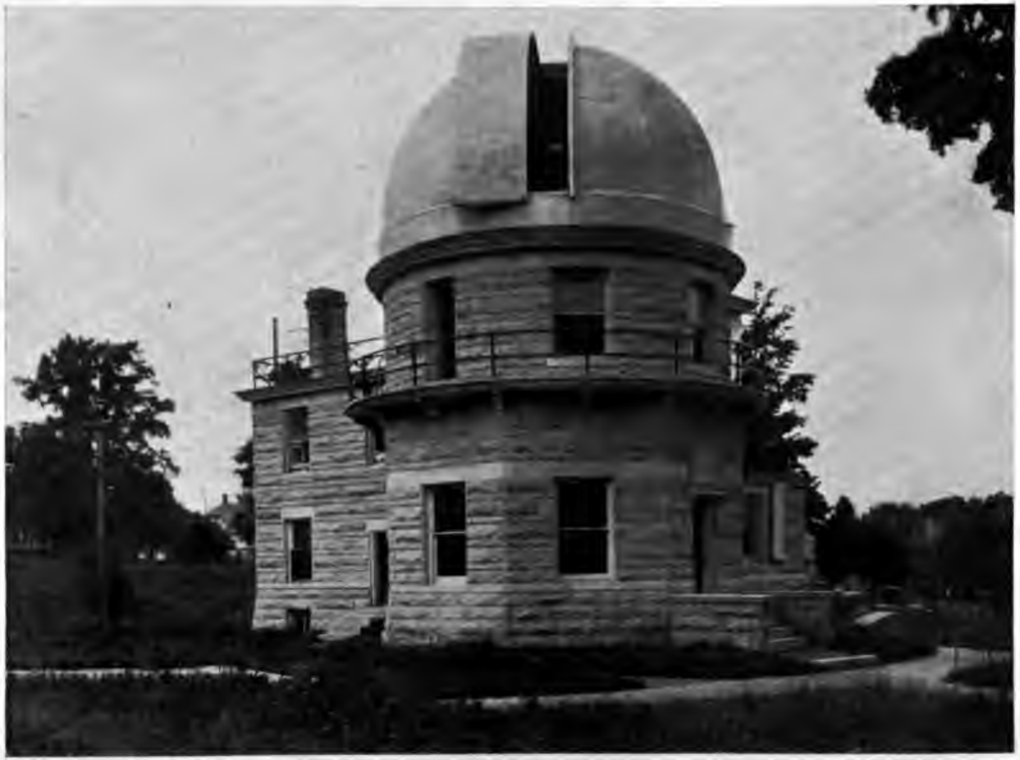

PUBLICATIONS

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THE KIRKWOOD OBSERVATORY OF INDIANA UNIVERSITY.

By John A. Miller, Director.

At its November meeting of 1899, the board of trustees of Indiana University appropriated a sum of money for the purchase of a telescope and some accessories, and for the erection of an observatory. The design of the board, that this equipment is to be used in part for instruction and in part for purposes of research, determined largely the character of the instruments afterwards purchased.

The observatory, a cut of which appears on the opposite page, is built of Indiana limestone, in which this region abounds, and was completed last winter. It contains six rooms — a library and computing-room; a lecture-room, which may be darkened at any time, equipped with a Colt electric lantern, lantern-slides, and other illustrative apparatus; a convenient dark-room; a transit-room; the dome-room, and a room similar to it and immediately below it.

The skeleton of the dome, which is twenty-six feet in diameter, is of white pine, and is built according to plans furnished by Messrs. Warner & Swasey, who also furnished the running mechanism. It is covered with tin. The performance of both dome and shutter is entirely satisfactory. In the dome-room is mounted a twelve-inch refractor. The objective is by Brashear, and is of high optical excellence, giving star-images which are free from fringes or distortion and on a black field. The mounting is by Warner & Swasey. It is provided with coarse and fine circles in both Declination and Right Ascension, the fine ones being provided with reading-microscopes and electric illumination. The star-dial, from which the Right Ascensions can be read directly, is of almost indispensable convenience. The driving-clock drives regularly, and the entire mounting is of the highest mechanical excellence. The telescope has as accessories a micrometer, by WARNER & SWASEY, provided with electric illumination; a polarizing helioscope, and a battery of positive and negative eye-pieces. The transit-room contains a small universal instrument by BAMBERG, a chronograph by FAUTH & COMPANY, a Bond sidereal chronometer, and a sidereal clock.

These instruments, together with a portrait lens of five inches aperture and a Browning equatorial of four inches aperture, which for many years have been the property of the university, constitute a nucleus around which the university authorities hope to collect a more complete equipment.

The observatory bears the name of Dr. DANIEL KIRKWOOD, the eminent astronomer, who for nearly half a century was a member of the faculty of the university, and who by his manly qualities won the lasting esteem of his students and colleagues, and by his devotion to his science a lasting name among his contemporaries.

The observatory was formally dedicated on May 15, 1901. The dedicatory address was given by Professor W. J. HUSSEY, Astronomer in the Lick Observatory. He spoke of "Astronomy and Modern Life." President JOSEPH SWAIN spoke of "Personal Recollections of Dr. KIRKWOOD."

We of the observatory take this opportunity to acknowledge our obligations to Professor HUSSEY for his thoughtful address and his kindly interest in our equipment.

DANIEL KIRKWOOD.*

By JOSEPH SWAIN.

At Riverside in California there died in his eighty-first year an aged man who was of more interest to the people who have known him and loved him (for to have known him was to love him) than all the groves of orange and palm-trees, than all the

* An address delivered at the dedication of the Kirkwood Observatory, University of Indiana, May 15, 1901.

snow-capped mountains, the Italian skies, the unequaled climate, or magnificent landscapes of that favored land. It is of this venerable man I wish to speak to you on this occasion.

The city of Riverside covers several square miles of territory and has hundreds of orange-groves and vineyards within its corporate limits. In one of these groves, seven acres in extent, lived DANIEL KIRKWOOD, the subject of this sketch.

While Professor KIRKWOOD passed his declining years in the picturesque surroundings of Southern California, it is not there that he made his name and lived the best part of his life. His twenty-seven years of active service in the interest of manhood, science, and higher education in general in Indiana are the brightest and best years of his life.

The esteem in which Dr. KIRKWOOD was held in Bloomington is indicated by the fact that the street leading to the university bears his name, and that every old citizen points out with evident pride the house in which he lived on the corner of College Avenue and Tenth Street. Indiana University has appropriately expressed its appreciation by naming one of the halls in his honor and also the new astronomical observatory.

DANIEL KIRKWOOD was of Scotch-Irish descent, his grandfather coming from Ireland in 1771, and settling in Delaware. His parents, JOHN and AGNES (HOPE) KIRKWOOD, were both born in this country. Professor KIRKWOOD was born in Hartford County, Maryland, September 27, 1814. His early life was spent on the farm, his first attendance at school being in his native county. Having little taste for farming, he entered the York County Academy, at York, Pennsylvania, in 1834. He had taught a country school at Hopewell, York County, the previous year. A pupil in this school wishing to study algebra, asked young KIRKWOOD to instruct him. A copy of BONNYCASTLE'S algebra was secured, and the two studied together, Mr. KIRKWOOD leading the way. Professor BRUNNOW, at one time professor of astronomy at Ann Arbor, once had a class of one in mathematical astronomy consisting of the afterward famous Professor WATSON. Professor BRUNNOW said he had never had so fine a class as this one either before or since. It is safe to say that no class of one ever had a more inspiring teacher of algebra than this young man in 1833 at Hopewell in Pennsylvania, for the young KIRKWOOD must have come to his first lessons in algebra with all the enthusiasm of youth and the ardor of "love at first sight." He was elected first assistant and mathematical instructor in York County Academy in 1838. While here he trained many students in mathematics, one of whom, SAMUEL R. FRANKLIN, afterward became superintendent of the Observatory at Washington. Professor KIRKWOOD resigned his position in 1843 to accept the principalship of the Lancaster High School, Pennsylvania, and a few years later he became principal of the Pottsville Academy. In 1845 he was married to Miss SARAH A. McNAIR, of Newton, Bucks County, Pennsylvania. He was professor of mathematics in Delaware College from 1851 to 1856, the last two years being its president. In speaking to me one day about this period of his presidency, he said, "Concerning that, the less said the better." He evidently did not enjoy the responsibility of the president's position. He was a student and teacher, and set a noble example which cannot be overestimated, but he did not like to assume or use authority. He was always the embodiment of loyalty to the institution he served, but begged to be excused from anything which brought him into public notice. He shrank intuitively from public gaze or appreciation. This was so strong that he could hardly be induced to give a public lecture, and never an impromptu address. I remember at one time there was a public gathering in the College Chapel at Bloomington. Some impromtu speeches had been made, and Dr. KIRKWOOD, being immensely popular with the students, was called upon by them to make a speech. The President of the University, who was presiding, stepped to him and asked him if he would not respond. He begged to be excused, and asked the President to say that as he had often excused the students from recitations in the class-room, he trusted they would now excuse him. This created a laugh at the expense of the students, and they did not call on him again that day.

He was a member of the Presbyterian Church, and was always a faithful attendant at its services. He was a teacher in the Sunday-school. For many years he taught a class of boys from twelve to fourteen years of age. I remember once he told me, with evident gratification, that these boys decided that they would not have any other teacher when he went away. He was a great reader of the Bible, preferring to read it in the Greek. In NORTHROP'S book, "A Cloud of Witnesses," there is a letter from Dr. KIRKWOOD which explains itself. It is as follows:—

"I am asked to give my opinion of Christ and the Bible. Let me say in answer to the old question, 'What think ye of Christ?' that his name is above every name. I regard him as the Divine Saviour of men. I accept him as my Saviour, and place all my hope of Salvation in him. I accept the Scriptures as a revelation of what man is to believe concerning God, and what duty God requires of man."

Professor KIRKWOOD deplored the fact that there has been a tendency to skepticism among some scientific men. He says:

"It will be noted, however, by careful observers that this tendency is more distinctly marked among specialists, men whose minds have been biased by continued and almost exclusive devotion to physical research, while the claims of Christianity and the evidence of its truth have been persistently ignored. But our own time is no exception to the historic fact that in all ages minds of the broadest culture have accepted Christianity."

He thought there is no necessary antagonism between physical science and Christianity, and the study of physical science was not of necessity prejudicial in the student himself to a personal acceptance of Christianity. Dr. KIRKWOOD had a profound belief in God and his controlling influence over the affairs of men. I remember being present at a certain organization when resolutions of sympathy were being passed on account of the death of a certain young man. Dr. KIRKWOOD had written the resolutions and had read them to the meeting. A member of the meeting objected to the form of his expressions as hackneyed and the sentiment as not being in accordance with the belief of all men. Dr. KIRKWOOD said with courtesy but decision and the emphasis of deep conviction, "I believe just that." He said no more, but the resolution was adopted as read.

I quote the following from an article by Professor ALEY:—

"His study of the stars has strengthened his belief in God. To his mind, with its faith strengthened by a firm grasp of the mightiest works of God, unbelief is impossible, and he can hardly understand how honest unbelief can exist in another. Some years ago he gave a beautiful demonstration before a class. A student asked: 'Is that always true?' 'Yes,' said he, 'as true as that there is a God in heaven.' 'But,' said the student, 'what would you say to him who does not believe in God?' Straightening up to his full height, and with glittering eye he said, 'I would try to keep my temper and get away as quickly as possible.' The writer well remembers his first visit to Bloomington. He went into a barber-shop, and, as it was a rainy day, there was quite a crowd of loafers, white and black, professional men and day laborers. By chance the conversation changed to men. Every man present found his ideal in DANIEL KIRKWOOD. No man ever received a higher tribute of praise. His life was so simple, so pure, and so true that the student, the philosopher, and the common man can all find in him the ideal."

A friend of mine once lived for a time in Dr. KIRKWOO house. One evening something attracted his attention in next room. He listened and found Dr. KIRKWOOD was readi the Scriptures aloud to his wife. The reading was followed a solemn prayer. My friend thought to himself: "Here i genuine Christian. He is following the teaching of Christ 'But thou when thou prayest, enter into thy closet, and wl thou hast shut thy door, pray to thy Father which is in sec and thy Father which seeth in secret shall reward thee openly.

The domestic life of Dr. KIRKWOOD was very beautiful. was at his best at home. His fireside was as attractive to l as his study. His wife was a quiet, domestic woman, who fo her chief enjoyment in her home and with her friends. She only interested in the scientific work of her husband as a lov and dutiful wife who was interested in everything connected w him. She was the devoted helper of a truly great man. Wl visitors happened in, she always wanted him to talk to them entertain them. She felt that she had done her part if encouraged him to talk. On such an occasion it was a genu pleasure to see the enjoyment she derived from his conversati

Professor KIRKWOOD was first introduced to the scien world by the publication, in 1849, of his analogy between periods of the rotations of the primary planets. The statem of the law is as follows: The square of the number of rotati made by a planet during one revolution around the Sun is p portional to the cube of the diameter of its sphere of attracti PROCTOR, the eminent English astronomer, gave KIRKWOOD name of "the KEPLER of America," after the announcem of KIRKWOOD'S Law. This was fitting, as the form of the is similar to KEPLER'S Third Law: The square of the num of the revolutions of a planet is proportional to the cube of mean distance from the Sun. Indeed, the form of the Law KEPLER first suggested to Dr. KIRKWOOD the form of this l This law has always been regarded by mathematicians as a c firmation of the Nebular Hypothesis. The law is an empir one, and has never been demonstrated by rigid mathemat analysis. It is now in the same stage of KEPLER'S Third I before it was shown to be the direct result of the Law Gravity. The mathematician who is able to give it a ri mathematical demonstration is sure of remembrance by a gr ful posterity.

When about fifty asteroids were known in the solar system, Professor KIRKWOOD conceived the notion that in those spaces where simple commensurability with *Jupiter* occurs, there must be gaps in the asteroid zone. It was then, however, only a theory, as the number of asteroids sufficient for its verification were not known. Yet on its first announcement it met with favor, and Mr. PROCTOR, the eminent astronomer, accepting Professor KIRKWOOD'S notion, wrote in 1870: "We may assume that when many more asteroids have been discovered, that the law will appear more distinctly." The number of asteroids known were then sufficient only to indicate the law; now the number discovered and orbits computed have reached 450. Professor KIRKWOOD has shown that these gaps actually exist and assigned a physical cause for them. He originally published his discoveries concerning these chasms in the Proceedings of the American Association for the Advancement of Science in 1866. Circumstances, however, which need not here be stated, induced Professor KIRKWOOD to give a résumé of his discussions in the Proceedings of the American Philosophical Society for 1883. From this paper the following is taken :—

"In those parts of the zone of minor planets where a simple relation of commensurability would obtain between the period of an asteroid and that of *Jupiter*, the original planetary matter was liable to great perturbations. The result of such disturbance by the powerful mass of *Jupiter* was the necessary formation of gaps in the asteroid zone."

Professor KIRKWOOD was the first to show that the divisions of *Saturn's* rings are due to the same cause as the gaps in the zone of asteroids. The treatise of Dr. MEYER, of Geneva, on *Saturn's* rings published in 1883, and leading to the same or a similar result, is a gratifying confirmation of Professor KIRKWOOD'S discovery.

He has contributed nearly two hundred articles to various scientific and popular journals. He is the author of a well-known book on comets and meteors, as well as an earlier book on meteoric astronomy. He is also the author of a little book on the asteroids. He was at one time mathematical editor of the *Indiana School Journal.* He also contributed popular articles for several years to the *Indianapolis Journal.* The astronomical articles in *Appleton's Annual Encyclopædia* were written for several years by him. *The Popular Science Monthly*, *The Analyst*, *American Journal of Science*, *The Sidereal Messenger*, *Nature*, and other journals, were always glad to get articles from his pen. Dr. KIRKWOOD'S writings are all characterized by simplicity, brevity, and purity. Such ability as he had to say clearly and forcibly what he had to say is possessed by few.

In September of 1889 he asked me to come to his study in the afternoon. I went and found that he wanted to see me about some books. He thought that the greater part of his library would no longer be useful to him, and that it should be placed where it would be of most service. He wanted to give some books to the college library, and he wanted me to select some that the university should buy. We found among his books several unpublished manuscripts. Professor GREEN and I suggested to him that the library would be glad to get these manuscripts, but he refused. They were manuscripts that he concluded, after mature consideration, he would not publish, and he feared their future publication if given to the library, so he consigned them to the fire, much to our disappointment. Dr. KIRKWOOD once having a clear notion of what he wished to do, was very slow to alter his determination. He made up his mind slowly and after very critical examination of the subject in hand, but relied upon his conclusion when reached. Once I suggested to him that he should have all his writings, scattered in numerous magazines, collected together and edited during his lifetime, so that it would be known just what he had done, and his articles would then be much handier for reference. His reply was this: "Anything that deserves to live will, and that which does not deserve it ought to die." He was not troubling himself about his future fame. His theory was that if he had not done anything worthy of future reference he wanted to be forgotten. He was not troubled by any thirst for a false and fictitious glory.

Dr. KIRKWOOD'S position among scientific men and non-scientific men was unusual. He had the respect and confidence of both alike. The most selfish man seemed to lose his selfishness in his presence. Every one seemed to instinctively feel that he was a great man, and a criticism upon him would be only acknowledging one's own lack of appreciation. While it is as a genial and good man that most of the people who have come into personal contact with Professor KIRKWOOD have known him, it is as a scientist that he is best known to the people of the United States and of Europe. He is probably better known in Great Britain than he is in America. He seemed to have through his

.tings the warm friendship of astronomers everywhere, even ›ugh they had not met him. Several years ago, when PROC-R, the eminent English astronomer, was in this country, this ident occurred: PROCTOR lectured in Indianapolis. After the ture a professor from a sister institution approached him and ited him to his town to lecture the next night. PROCTOR said: ꟿo; I came to America to see Dr. KIRKWOOD. To-morrow ny opportunity, and I am going to Bloomington to see him."

Eighteen years ago, when I was an assistant of Dr. KIRK-)OD, I wrote and published this paragraph:—

"'When I die, I want to go where Dr. KIRKWOOD goes,' was the ıple eulogy of one of his admirers. Whatever may be said of this ıtiment, certain it is that during fifty years as a teacher, he has gained m his students such universal love and admiration as few men can ioy, and while as a mathematician he has made many valuable contri-tions to science, as a genial, temperate, and genuine man, he has .ved the problem of gracefully growing old."

In intellect he was keen, logical, and far-seeing. In integrity was without reproach. He was "spotless before the world." private character he was pure as an infant. He was in sym-thy with humanity. He was as natural as a child and as free ›m self-conceit as the "lilies of the field." He saw and spoke ɜ truth. The laws of Nature were to him the laws of God. ıe heavens indeed declared His glory. In revealing the secrets the stars he revealed the beauty of his life. KIRKWOOD the entist we admire, but KIRKWOOD the man we love. These aracteristics made DANIEL KIRKWOOD one of the greatest of diana's roll of heroes and one of the most lovable of men any country or age.

PLANETARY PHENOMENA FOR SEPTEMBER, OCTOBER, NOVEMBER, AND DECEMBER, 1901.

By MALCOLM MCNEILL.

SEPTEMBER.

The Sun crosses the celestial equator and autumn begins :ptember 23d, 10 A.M. Pacific time.

Mercury is an evening star throughout the month, having ssed superior conjunction on August 27th. At the close of the month it is well out toward east elongation, but the gre southern declination of the planet makes the interval betwe sunset and the setting of the planet too short for naked-e visibility of the planet.

Venus is an evening star. It increases its distance from t Sun from 32° to 37°, and it remains above the horizon a fe minutes longer after sunset than during August. At the end September the interval is about an hour and a half. It moves 3 east and 14° south through *Virgo* into *Libra*. On Septemb 8th it passes about 3° north of the first-magnitude star *Spica*.

Mars is much nearer the Sun and sets earlier than duri August. Its distance from us increases about twelve millio of miles, and it is about twice as far from us as we are from t Sun. Its apparent motion among the stars is 20° east and south from *Virgo* into *Libra*, and at the end of the month it about 4° east of *Venus*, which is rapidly overtaking it.

Jupiter and *Saturn* remain in *Sagittarius*, and are quite con spicuous in the southwestern sky in the evenings. *Jupiter* ha ceased his retrograde motion and is again moving eastward, bu not rapidly as yet, making about 1° 41′ during the month *Saturn* keeps up his westward motion until September 14th, an then begins to move eastward, but the whole motion is onl about 15′, and, as far as naked-eye observations show, the plan is practically stationary among the stars. *Jupiter* and *Satur* approach each other a little more than 1°, and on Septemb 30th they are not quite 6° apart.

Uranus is about two hours' motion ahead of *Jupiter* an *Saturn*, and its distance from the Sun is getting to be too sma for convenient evening observations. It remains above t horizon until nearly 9 P.M. on September 30th; but its small si makes observation difficult unless the planet is at a good altitud

Neptune is an early morning object.

OCTOBER.

There will be a partial eclipse of the Moon, on October 27th, n visible in any part of the western hemisphere except Alaska, b visible generally throughout the eastern hemisphere, except i western Europe. At the maximum only about one quarter the Moon's diameter will be covered.

Mercury is an evening star, and comes to greatest east elong tion on the morning of October 12th; but its very great southe leclination (12° south of the Sun) makes the interval between he setting of the Sun and planet less than one hour, and although he elongation (25°) is comparatively large, being only a fortnight rom aphelion, the planet will scarcely be visible to the naked eye.

Venus is increasing its apparent distance from the Sun, and y the close of the month the elongation will be more than 40°. The interval from sunset to the setting of the planet increases, nd is well over two hours by the end of the month. The planet noves about 35° eastward and 8° southward among the stars from *Libra* through *Scorpio* and into *Ophiuchus*. On the morning of October 9th it overtakes and passes *Mars*, also moving in the same general direction but more slowly. At the time of nearest approach *Venus* is a little less than 1° south of *Mars*. *Venus* also is in conjunction with *Uranus* on the morning of October 25th, the former being 2° 21′ south.

Mars is still in the southwestern sky in the early evening, but ets less than two hours after sunset, and has become so faint as o be no longer conspicuous. It is nearly at its maximum disance from us, but will not reach it for several months. It moves bout 21° east and 5° south from *Libra* through *Scorpio*.

Jupiter and *Saturn* still keep their position in *Sagittarius*, nd by the close of the month remain above the horizon less than our hours after sunset. Both are moving eastward among the tars, *Jupiter* 4° and *Saturn* a little more than 1° during the nonth, and by the end they are less than 3° apart.

Uranus is nearer the Sun than during September, and by the nd of the month sets about two hours after sunset. It is rather oo low down to be seen with the naked eye.

Neptune is rising earlier, and is well up during the late evening.

NOVEMBER.

There will be an annular eclipse of the Sun on November 10th, not visible in the western hemisphere. The central line runs from the Mediterranean Sea through Egypt, Arabia, the Indian Ocean, just touching southern Hindustan and Siam, and ending in the Philippines.

Mercury passes inferior conjunction with the Sun and becomes a morning star on November 4th. It rapidly recedes from the Sun, and after November 11th it rises more than an hour before sunrise. It reaches greatest west elongation on November 20th, and then rises more than an hour and a half before sunrise. This is the best opportunity of the year for seeing *Mercury* as a morning star.

All of the other planets, except *Neptune*, are in the south-western sky in the early evening, but some of them are too near the Sun for easy observation. *Venus* reaches nearly its maximum distance from the Sun, and by the close of the month sets more than three hours after sunset. It moves about 33° westward and 2° northward from *Ophiuchus* through *Sagittarius* into *Capricorn*, passes *Jupiter* on November 17th, and *Saturn* on November 18th. For several days the three planets are near each other, *Venus* being about 3° south of the other two. This close conjunction of three bright planets is a very unusual occurrence.

Mars is down below *Venus*, and toward the close of the month will not be a very easy object, but can still be made out in good weather conditions. It moves eastward about 22° from *Scorpio* through *Ophiuchus* into *Sagittarius*. It passes *Uranus* less than 1° south on the night of November 3–4th, and at the close of the month is about 10° from *Jupiter* and *Saturn*.

Jupiter and *Saturn* are still high enough to be seen in the early evening. Both are moving rapidly eastward from the constellation *Sagittarius* toward *Capricorn*. They come to conjunction on the evening of November 27th, *Jupiter* then being 0° 27′ south of *Saturn*, a distance rather less than the Moon's diameter. At the beginning of the month *Jupiter* was about 3° west of *Saturn*.

Uranus is drawing closer to the Sun and by the end of the month sets only a half an hour after sunset.

DECEMBER.

The Sun passes the solstice and winter begins December 22d, 4 A.M., P. S. T.

The Earth is in perihelion December 31st, 10 P.M., P. S. T.

Mercury is a morning star at the beginning of the month, rising about an hour and a half before sunrise, but is approaching the Sun. The interval between the rising of the planet and the Sun is, however, more than an hour until after December 10th. After that it is too near the Sun to be seen, and by the end of the month it has nearly reached superior conjunction. It is in conjunction with *Uranus* on the morning of December 18th.

Venus reaches its greatest east elongation on December 4th. It is then 47° 19′ from the Sun, and by the end of the month the ce will have diminished about 4°. Owing to the relative ıs of the Sun and planet in declination, however, the interval ɜn sunset and the setting of the planet will go on increasing ghout the month, being more than three hours and a halt l the close. *Venus* has been gradually increasing in ness as it moved out toward greatest elongation, and will rther increase until about half-way between that point and r conjunction. The maximum will occur during January,

ırs is gradually being overtaken by the Sun in their common ırd motion, but will not set until about an hour and a half unset throughout the month. It is growing so faint that er conditions must be very good in order to see it. It 1° 19′ south of *Saturn* on the morning of December 14th, ° 52′ south of *Jupiter* on the morning of December 17th. everal days the three planets are very close together.

iter and *Saturn* are drawing close to the Sun, and by the of the month both set less than an hour after sunset. It e hardly possible to see *Saturn* for the last week or so, but *r*, on account of its greater brightness, may remain visible ghout the month. Both planets are still moving eastward g the stars, but the greater motion of *Jupiter* causes them ıarate, and on December 31st *Jupiter* will be about 4° east *turn*.

ranus is too near the Sun to be seen and passes conjunction e afternoon of December 9th.

ptune is in opposition with the Sun on December 24th.

September–October, 1901.

Phases of the Moon, P. S. T.

Last Quarter . . .	Sept. 5,	5h	27m	A. M.
New Moon . . .	Sept. 12,	1	18	P. M.
First Quarter . . .	Sept. 20,	5	33	
Full Moon . . .	Sept. 27,	9	36	
Last Quarter . . .	Oct. 4,	12	52	
New Moon . . .	Oct. 12,	5	11	A. M.
First Quarter . . .	Oct. 20,	9	58	
Full Moon . . .	Oct. 27,	7	6	

The Sun.

1901.		R. A.	Declination.	Rises.	Transits.	Sets.
Sept.	1,	10h 40m	+ 8° 27′	5h 31m A.M.	noon	6h 29m P.M.
	11,	11 16	+ 4 44	5 41	11h 57m A.M.	6 13
	21,	11 52	+ 0 53	5 50	11 53	5 56
Oct.	1,	12 28	— 3 1	6 0	11 50	5 40
	11,	13 4	— 6 52	6 11	11 47	5 23
	21,	13 42	— 10 33	6 21	11 45	5 9
	31,	14 20	— 13 59	6 32	11 44	4 56

Mercury.

Sept.	1,	10 59	+ 8 14	5 51 A.M.	12 19 P.M.	6 47 P.M.
	11,	12 2	+ 0 26	6 42	12 43	6 44
	21,	12 59	— 6 55	7 24	1 0	6 36
Oct.	1,	13 51	— 13 18	7 59	1 13	6 27
	11,	14 36	— 18 13	8 22	1 18	6 14
	21,	15 6	— 20 44	8 23	1 9	5 55
	31,	14 55	— 18 29	7 24	12 19	5 14

Venus.

Sept.	1,	12 41	— 3 48	8 13 A.M.	2 1 P.M.	7 49 P.M.
	11,	13 25	— 8 52	8 36	2 5	7 34
	21,	14 9	— 13 38	8 58	2 11	7 24
Oct.	1,	14 56	— 17 54	9 20	2 17	7 14
	11,	15 43	— 21 28	9 43	2 26	7 9
	21,	16 33	— 24 9	10 4	2 36	7 8
	31,	17 23	— 25 47	10 23	2 47	7 11

Mars.

Sept.	1,	13 53	— 11 58	9 54 A.M.	3 13 P.M.	8 32 P.M.
	11,	14 18	— 14 19	9 48	2 59	8 10
	21,	14 45	— 16 33	9 44	2 46	7 48
Oct.	1,	15 13	— 18 36	9 39	2 34	7 29
	11,	15 42	— 20 25	9 36	2 24	7 11
	21,	16 12	— 21 58	9 34	2 15	6 56
	31,	16 43	— 23 11	9 30	2 6	6 42

Jupiter.

Sept.	1,	18 14	— 23 31	2 59 P.M.	7 33 P.M.	12 7 A.M.
Oct.	1,	18 21	— 23 31	1 8	5 42	10 16 P.M.
Nov.	1,	18 39	— 23 21	11 23 A.M.	3 58	8 33

SATURN.

Sept.	1,	18 43	−22 43	3 23 P.M.	8 2 P.M.	12 41 A.M.
Oct.	1,	18 44	−22 46	1 25	6 4	10 43 P.M.
Nov.	1,	18 50	−22 41	11 30 A.M.	4 9	8 48

URANUS.

Sept.	1,	16 46	−22 23	1 26 P.M.	6 5 P.M.	10 44 P.M.
Oct.	1,	16 49	−22 28	11 31 A.M.	4 10	8 49
Nov.	1,	16 54	−22 38	9 36	2 14	6 52

NEPTUNE.

Sept.	1,	6 5	+22 17	12 6 A.M.	7 26 A.M.	2 46 P.M.
Oct.	1,	6 6	+22 16	10 9 P.M.	5 29	12 49
Nov.	1,	6 6	+22 15	8 6	3 26	10 46 A.M.

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off right-hand limb as seen in an inverting telescope.)

III, R,	Sept.	2,	4^h 39^m P.M.	I, R,	Oct.	1,	2^h 33^m P.M.
II, R,		4,	8 46	II, R,		6,	8 38
I, R,		6,	7 50	I, R,		8,	4 28
III, D,		9,	5 35	III, R,		15,	4 45
III, R,		9,	8 40	I, R,		15,	6 23
IV, D,		11,	10 39	III, D,		22,	5 35
II, R,		11,	11 24	III, R,		22,	8 45
I, R,		13,	9 45	I, R,		24,	2 47
I, R,		15,	4 14	II, R,		24,	3 13
III, D,		16,	9 35	I, R,		31,	4 42
II, R,		22,	3 22	II, R,		31,	5 52
I, R,		22,	6 9				
IV, D,		28,	4 40				
IV, R,		28,	7 47				
II, R,		29,	6 0				
I, R,		29,	8 4				

NOVEMBER–DECEMBER, 1901.

PHASES OF THE MOON, P. S. T.

Last Quarter, . . .	Nov.	2,	11^h	24^m P.M.
New Moon, . . .	Nov.	10,	11	34
First Quarter, . . .	Nov.	19,	12	23 A.M.
Full Moon, . . .	Nov.	25,	5	18 P.M.
Last Quarter, . . .	Dec.	2,	1	50
New Moon, . . .	Dec.	10,	6	53
First Quarter, . . .	Dec.	18,	12	35
Full Moon, . . .	Dec.	25,	4	16 A.M.

The Sun.

1901.		R. A.	Declination.	Rises.	Transits.	Sets.
Nov.	1,	14h 24m	— 14° 18′	6h 33m A.M.	11h 44m A.M.	4h 55m P.M.
	11,	15 4	— 17 19	6 44	11 44	4 44
	21,	15 45	— 19 50	6 57	11 46	4 35
Dec.	1,	16 28	— 21 45	7 7	11 49	4 31
	11,	17 11	— 22 59	7 16	11 53	4 30
	21,	17 55	— 23 27	7 23	11 58	4 33
	31,	18 40	— 23 8	7 27	12 3 P.M.	4 39

Mercury.

Nov.	1,	14 51	— 17 53	7 14 A.M.	12 11 P.M.	5 8 P.M.
	11,	14 13	— 11 35	5 32	10 53 A.M.	4 14
	21,	14 29	— 12 14	5 12	10 30	3 48
Dec.	1,	15 19	— 16 47	5 39	10 41	3 43
	11,	16 20	— 21 10	6 16	11 2	3 48
	21,	17 26	— 24 3	6 57	11 29	4 1
	31,	18 36	— 24 53	7 32	noon	4 28

Venus.

Nov.	1,	17 28	— 25 54	10 25 A.M.	2 48 P.M.	7 11 P.M.
	11,	18 18	— 26 17	10 37	2 59	7 21
	21,	19 7	— 25 31	10 43	3 8	7 33
Dec.	1,	19 54	— 23 43	10 41	3 15	7 49
	11,	20 36	— 21 4	10 32	3 17	8 2
	21,	21 12	— 17 46	10 17	3 15	8 13
	31,	21 43	— 14 9	9 53	3 5	8 17

Mars.

Nov.	1,	16 46	— 23 17	9 29 A.M.	2 5 P.M.	6 41 P.M.
	11,	17 18	— 24 5	9 26	1 58	6 30
	21,	17 51	— 24 28	9 22	1 52	6 22
Dec.	1,	18 24	— 24 24	9 16	1 46	6 16
	11,	18 58	— 23 53	9 8	1 40	6 12
	21,	19 32	— 22 55	8 57	1 34	6 11
	31,	20 5	— 21 30	8 45	1 28	6 11

Jupiter.

Nov.	1,	18 39	— 23 21	11 23 A.M.	3 58 P.M.	8 33 P.M.
Dec.	1,	19 3	— 22 53	9 47	2 24	7 1
Jan.	1,	19 33	— 22 0	8 11	12 52	5 33

SATURN.

1,	18 50	−22 41	11 30 A.M.	4 9 P.M.	8 48 P.M.
1,	19 2	−22 28	9 44	2 23	7 2
1,	19 17	−22 6	7 55	12 36	5 17

URANUS.

1,	16 54	−22 38	9 35 A.M.	2 14 P.M.	6 53 P.M.
1,	17 2	−22 49	7 45	12 23	5 1
1,	17 10	−23 0	5 52	10 29 A.M.	3 6

NEPTUNE.

1,	6 6	+22 15	8 6 P.M.	3 26 A.M.	10 46 A.M.
1,	6 3	+22 15	6 6	1 26	8 46
1,	5 59	+22 15	3 57	11 17 P.M.	6 37

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off right-hand limb as seen in an inverting telescope.)

R, Nov.	7,	6^h 37^m P.M.	II, R, Dec.	1,	5^h 43^m P.M.
R,	16,	3 0	IV, D,	4,	4 51
R,	23,	4 55	I, R,	9,	3 13
R,	25,	3 6	I, R,	16,	5 8
R,	27,	4 50			
R,	30,	6 50			

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

CAPELLA AGAIN.

Since the discovery that *Capella* is a spectroscopic binary it has been of much interest to see if it is also a telescopic double star. I have given the result of my examination of it for 1900, having this object in view, in No. 484 of the *Astronomical Journal* and in No. 75 of these *Publications*. I there stated that I had examined *Capella* on several afternoons early in June, 1900, with the 36-inch refractor without obtaining any visual evidence of its being a double star. The result then obtained was not regarded as conclusive, for the seeing, though good, was not excellent, according to our standards.

On the nights of August 2d and 5th, 1900, I made further examinations with the same instrument, using powers of 1000, 1500, 1900, and 2600. With all these powers the star appeared round. On these dates the seeing was excellent, and stood all these powers perfectly. On the last date the seeing was perhaps the best. With conditions such as then prevailed an elongation due to a distance of a tenth of a second would have been readily perceptible with the lowest power used, and a considerably smaller distance would have given an unmistakable elongation with the higher powers. On the last date glass color-screens of various shades were used a part of the time to reduce the light. Mr. PERRINE at this time also made careful examinations with all of the powers without detecting any elongation.

According to the elements of the orbit of this binary as derived from the spectroscopic observations, the most favorable dates for detecting an elongation visually are about April 15th, June 6th, July 28th, September 18th, and November 9th, 1900, and April 14th, June 5th, July 27th, September 17th, and November 8th, 1901. On account of the orbit's being nearly circular, the

* Lick Astronomical Department of the University of California.

pparent distance has nearly its maximum value for a few days n either side of the dates given.

I have recently examined *Capella* again on two good nights. t the time of the last examination, August 2, 1901, the seeing as excellent and all the powers mentioned above were successvely used. Glass color-screens of different shades were used at mes to reduce the light. At the time of this examination the enith distance of *Capella* varied from 45° to 38°. With all owers the central disc of the star's image was sharply defined, ery small, and apparently perfectly round.

W. J. HUSSEY.

TIMES OF THE ELONGATIONS OF *MIMAS*.

While making measurements of the relative positions of the nner satellites of *Saturn* during the present summer, I noticed that *Mimas* reached its greatest eastern and western elongations about .2 hours earlier than the predicted times given in the American Ephemeris. On writing to Dr. HARSHMAN, Director of the Nautical Almanac Office, in reference to the matter, he informed ne that the predicted times were based upon Professor HALL'S lements. He also furnished me the systematic corrections necesary to reduce the times of elongation as derived from Professor HALL'S elements to those derived from Dr. H. STRUVE'S elenents, as follows:—

1900.0	— 3ʰ.68
1901.0	— 4 .02
1902.0	— 4 .37
1903.0	— 4 .72
1904.0	— 5 .06

The times of elongation of *Mimas* for the years 1900, 1901, 902, and 1903, as given in the American Ephemeris, are based pon HALL'S elements. Those for 1904 are based upon STRUVE'S lements. From my measures it appears that STRUVE'S elements epresent the motion closely.

W. J. HUSSEY.

DUPLICITY OF *66 TAURI* AND OF THE PRINCIPAL COMPONENT OF Σ 2339.

While examining *66 Tauri* with the 12-inch telescope, Februry 24, 1900, I discovered that it is a close pair. Several months passed before I measured it, and it is only recently that second and third measures have been obtained. These measures give —

1900.920	22°.7	0″.26	5.8	6.0
1901.584	205 .3	0 .24	6.0	6.0
.658	23 .6	0 .25	6.0	6.0

The magnitudes of the two components are so nearly the same that I have not been able to determine the quadrant with certainty.

66 Tauri is a naked-eye star. Its proper motion has been determined, and, according to AUWERS, is given by the equations —

$$\mu = -0^s.0027, \qquad \mu' = -0''.004.$$

On account of the character of the pair and by reason of its proper motion, it is probable that *66 Tauri* is a binary.

I have recently found the principal component of Σ 2339 to be a close pair. The star did not appear to be quite round to me with the 12-inch telescope. On this account I examined it with the 36-inch refractor, which clearly showed it double. I have made the following measures of it:—

1901.603	85°.2	0″.20	8.0	8.2
.608	87 .0	0 .18	. .	. .
.623	86 .7	0 .20	8.0	8.2

The components of this pair are a little unequal in brightness so that the quadrant is readily determinable.

I have referred these stars to Professor BURNHAM, who has kindly looked them up for me, and states that they are both new.

W. J. HUSSEY.

OBSERVATIONS OF THE SPECTROSCOPIC BINARY *η PEGASI*.*

The binary character of *η Pegasi* was discovered in August 1898, from observations made with the Mills spectroscope, and announced in the *Astrophysical Journal* for October, 1898. It was the first one of some thirty-five spectroscopic binary systems discovered in the past three years with this efficient instrument. As a basis for determining the orbit of the bright component of

* From Lick Observatory Bulletin, No. 5

system, the following velocities in the line of sight were ɪerved:—

Date. Greenwich M. T.			Velocity. Kms.	No.	Date. Greenwich M. T.			Velocity. Kms.
1896,	Aug.	27 8,	+ 7 10	16	1899,	June,	21.0,	— 8.02
	Sept.	23.7,	+ 5 10	17			27.0,	— 8.31
1897,	July	8 9.	— 6.37	18		July,	26.9,	— 7.14
	Sept.	28.7,	— 2.21	19		Sept.	6.8,	— 6.81
1898,	Aug.	29.8,	+16.54	20		Dec.	19.7,	— 3 86
		30.8,	+15.62	21			25.7,	— 1.44
	Sept.	4.7,	+16.46	22	1900,	May,	14 0,	+10.89
		15.8,	+15 74	23		June,	7.0,	+14 06
	Oct.	18.7,	+10.99	24		Aug.	1.9,	+18.89
		24 8,	+11 51	25		Sept.	25.7,	+21 40
		26.8,	+10.83	26		Oct.	9 7,	+20.37
	Nov.	28 7,	+ 6.06	27			24 8,	+19.88
1899,	Jan.	23.6,	— 0.84	28		Dec.	11.7,	+15.17
	May,	2.0,	— 6 44	29	1901,	May,	9.0,	— 0.18
		9.0,	— 5 94					

The period of revolution of the system was early found to be ›ut two years and a quarter. The observations are distributed :r more than two complete periods.

The probable error of one observation, ± 0.47 kilometer, ermined by Dr. CRAWFORD, is very satisfactory under the :umstances. It is based upon all the observations secured. ese include those made in 1896, with a very imperfect camera s. The first thirteen observations were obtained before the :cial temperature control was installed. The thirteenth observa- n was made when the star was low in the west, in the early :ning, with the temperature changing rapidly. Experience ; shown that observations taken under such conditions are not .y useless, but are apt to be harmful, and No. 13 might well /e been rejected. It furnishes the largest residual, and its ection would have reduced very materially the computed ›bable error of a single observation.

The spectra were measured, in all cases, soon after they re secured, in six different years. The 26th, 27th, and 28th .tes were measured and reduced by Dr. REESE, and the naining twenty-six plates by myself. If they could have :n measured in quick succession, by one observer, no doubt : results would yield a much smaller computed probable or, as the personal habits of measurement change appreci- y with time.

Messrs. HUSSEY and AITKEN have carefully examined *η Pegasi* with the 36-inch refractor, but have been unable to detect the companion-star.

W. W. CAMPBELL.

1901, July 24.

THE ORBIT OF THE SPECTROSCOPIC BINARY *η PEGASI.*

[ABSTRACT.]*

This orbit of *η Pegasi* is based upon the twenty-nine observations given by Director CAMPBELL. Of these, several groups have been formed into normal positions by taking the mean of their dates and of their velocities. These groups are Nos. 5, 6, 7, 8; 9, 10, 11; 14, 15; 16, 17; and 20, 21. All of the other observations have been given weight unity, except No. 13, to which, for reasons given by Director CAMPBELL, weight one-half has been assigned.

From the plot of these observations the first approximation to the period was taken to be 815 days. By adjusting the upper and the lower areas to equality by means of a planimeter, the velocity of the center of the mass was found to be $+4.15^{km}$.

Using the formulæ and notation of LEHMANN-FILHÉS, a set of preliminary constants and elements was obtained. From these elements and the residuals resulting from them twenty-one weighted homogeneous observation equations were set up. These were solved by the method of Least Squares and a second set of elements obtained. From the differences between the residuals as found from these elements and from the observation equations, it was seen that the terms involving the second powers of the increments in the differential equations of condition were not negligible. This discrepancy necessitated another solution starting from the second elements, which resulted in the set of Final Elements here given :—

FINAL ELEMENTS.

$K =$	14.20^{km}	$\pm 0.13^{km}$
$e =$	0.1548	± 0.0106
$\omega =$	$5^{\circ}.605$	$\pm 3^{\circ}.708$
$\mu =$	0.007681 rad	± 0.000020 rad
$=$	$0^{\circ}.44009$	$\pm 0^{\circ}.00117$
$T =$	1898 June 29.7	± 8.1 days
$=$	1900 Sept 25.7	
$V_0 =$	$+4.31^{km}$	$\pm 0.10^{km}$
$U =$	818.0 days	± 2.2 days
$a \sin i =$	157,800,000	

RUSSELL TRACY CRAWFORD.

* The detailed paper is printed in *Bulletin* No. 5 of the Lick Observatory.

New Double Stars.

Systematic search for new double stars has formed a part of my observing programme for the past two years, with the result, so far, of the discovery of 250 pairs not previously known. Two hundred and three of these pairs have been published in *A. N.* 3635 and 3668, and in *Bulletin* No. 3 of the Lick Observatory. Attention has been called to some of the more important pairs of the first two lists in previous numbers of these *Publications*.

The third list, published in Lick Observatory *Bulletin* No. 3, contains 94 pairs, classified with respect to the distance between their components as follows:—

Under 0″.25	3
0 .50	23
1 .00	47
2 .00	73
Over 5 .00	1

Two of these pairs are formed from the division of the principal component of the known double stars H 846 and Σ 2527.

The measures are:—

A 143.

R. A. $12^h\ 10^m\ 46^s$; Decl. $-7^\circ\ 26'$.

A and *B* (New).

1901.27	148°.8	1″.00	9.2–10.3	3^n.

A and *C* = H 846.

1901.26	113°.4	13″.02	9.2–11.5	2^n.

A 159.

R. A. $19^h\ 23^m\ 0^s$; Decl. $+20^\circ\ 28'$.

A and *B* (New).

1900.65	335°.0	0″.78	8.4–11.7	3^n.

A and *C* = Σ 2527.

1900.61	18°.3	4″.26	8.4–9.5	1^n.

The two closest pairs in the list are A 162, and A 194, for which I obtain the following results:—

A 162.

R. A. $19^h\ 30^m\ 47^s$; Decl. $+23^\circ\ 15'$.

1900.66	144°.6	0″.21	8.2–8.2	3^n.

A 194.

R. A. 22^h 57^m 28^s; Decl. $+47°$ 28′.

1900.94	97°.7	0″.18	8.0–8.0	4^n.

Three of the pairs discovered since the lists mentioned above were printed consist of additional components to previously known double stars.

Their measures are as follows: —

R. A. 19^h 7^m 43^s; Decl. $+24°$ 23′ (1880.0).

	A and *B* (New).			
1901.35	288°.6	2″.79	8.0–13.5	3^n.
	A and *C* = Ho. 446.			
1901.35	48°.3	5″.32	8.0–12.0	3^n.
	A and *D* (New).			
1901.35	112°.0	33″.6	8.0–15.5	1^n.
	D and *E* (New).			
1901.35	118°.8	5″.38	15.5–16.0	1^n.

R. A. 20^h 3^m 38^s; Decl. $+35°$ 26′ (1900.0).

	A and *B* = OΣ 398.			
1901.53	77°.3	0″.96	7.7–9.7	1^n.
	A and *C* (New).			
1901.53	132°.0	5″.23	7.7–15.0	1^n.

R. A. 20^h 7^m 25^s; Decl. $+34°$ 7′ (1880.0).

	A and *B* (New).			
1901.41	206°.2	0″.21	7.6–7.8	3^n.
	AB and *C* = Ho. 121.			
1901.40	17°.0	22″.80	7.0–11.5	2^n.

September 5, 1901. R. G. AITKEN.

SOME RECENT RESULTS SECURED WITH THE MILLS SPECTROGRAPH.*

The results given below are a few of those recently established by the Mills spectrograph, used in connection with the 36-inch refracting telescope. The majority of the photographs upon which the results depend were made by Assistant Astronomer W. H. WRIGHT, and the remainder by DR. REESE and myself.

June 20, 1901. W. W. CAMPBELL.

* Reprinted from *Bulletin* No. 4 of the Lick Observatory.

I.—A LIST OF SIX STARS WHOSE VELOCITIES IN THE LINE OF SIGHT ARE VARIABLE.

The following six spectroscopic binaries, discovered with the Mills spectrograph, are additional to the twenty-five already announced.

π Cephei ($\alpha = 23^h\ 05^m$; $\delta = +74° 51'$).

The binary character of this star was suspected in August, 1899, from the fact that the approximate measures and reductions of the first and third plates showed a range of four kilometers in the observed velocities. Later plates confirmed the fact of the variation. The observations to date are as follows:—

Date.			Velocity.
1899	August	8	— 33^{km}
	August	23	— 36
	August	29	— 37
1900	October	7	— 5
	December	24	— 23

o₁ 31 Cygni ($\alpha = 20^h\ 10^m$; $\delta = +46° 26'$).

The variability was detected in July, 1900, from the third plate.

Date.			Velocity.
1899	June	20	— 12^{km}
	July	2	— 11
1900	July	30	— 3
	August	12	— 3
	October	7	± 0
1901	June	5	+ 3

This star was discovered to have a composite spectrum by Harvard College Observatory. [*Annals H. C. O.*, XXVIII, 93.]

ξ Piscium ($\alpha = 1^h\ 48^m$; $\delta = +2° 42'$).

The variable velocity of this star was discovered in September, 1900, from measures of the third plate.

Date.			Velocity.
1899	September	5	+ 25^{km}
	September	19	+ 27
1900	September	17	+ 33
	December	26	+ 35

τ *Persei* ($\alpha = 2^h\ 47^m$; $\delta = 52^\circ\ 22'$).

The variable velocity of τ *Persei* was discovered from the fourth plate of its spectrum in October, 1900.

Date.			Velocity.
1898	October	26	$+10^{km}$
	November	14	+ 8
	November	28	+ 8
1900	October	15	— 2
	October	31	— 3
	December	17	— 4

It was discovered at Harvard College Observatory that this star has a composite spectrum. [*Annals H. C. O.*, XXVIII, 93.]

ξ_1 *Ceti* ($\alpha = 2^h\ 08^m$; $\delta = 8^\circ\ 23'$).

The variable velocity of this star was discovered from the fourth plate in October, 1900.

Date.			Velocity.
1897	October	27	-9^{km}
1898	October	10	— 7
	October	17	— 8
1900	October	29	+ 4
	December	4	+ 1

ϵ *Hydræ* ($\alpha = 8^h\ 42^m$; $\delta = +6^\circ\ 48'$).

The variable velocity of this star was detected from the third plate in December, 1900.

Date.			Velocity.
1899	November	27	$+43^{km}$
	December	26	+ 43
1900	December	3	+ 35
	December	24	+ 40
1901	April	23	+ 32

II.—RADIAL VELOCITIES IN THE SYSTEM OF δ *EQUULEI.*

This is one of the most interesting double stars known, discovered by OTTO STRUVE in 1852. Its period of revolution was supposed to be 11.4 years. It was placed on the observing program for the Mills spectrograph, and its radial velocity was observed as follows:—

Date.			Velocity.
1900	June	25	-14^{km}
	July	9	— 13

o peculiarities, such as doubling of the lines due to the two ›onents, were apparent in the spectrum. This result was ipated, as the two components were known to be moving ɔximately parallel to the line of nodes of their orbit; that is, ;ht angles to the line of sight.

ı September, 1900, Assistant Astronomer AITKEN'S observ ns of this star showed that the long-accepted orbits were tisfactory [*Publ. A. S. P.*, XII, 255–7]; and Astronomer SEY'S investigations rendered it probable that the period is 5.7 years [*Publ. A. S. P.*, XII, 215–223].

pecial efforts have been made to secure spectrographic obser›ns of δ *Equulei* this spring, with a view to solving the diffi- question of the star's period. A few successful negatives : been obtained in the past two months. The spectra of the components are clearly shown, with displacements corre-ıding to a relative velocity at present of about 35 kilometers second. If the distance between the corresponding lines 'eases, and vanishes, in the next few months, we shall have :lusive proof that the period of the star is in the vicinity ;.7 years; otherwise, the longer period should have the erence.

III.—RADIAL VELOCITIES IN THE SYSTEM OF *POLARIS*.

t was discovered in August, 1899, from observations made the Mills spectrograph, that α *Ursæ Minoris (Polaris)* is a ɛ star. A few observations secured that month showed at that the bright component was moving around the center ass of itself and an invisible companion in a period of about ys 23 hours. Six observations secured in 1896, extending three months, were best satisfied on the assumption that period is $3^d\ 23^h\ 15^m$. A comparison of the 1896 and 1899 rvations furnished a period of $3^d\ 23^h\ 14^m.3$.

'he velocity of the center of mass of this system varied from 8.0^{km} per second in 1896 to — 11.8^{km} in 1899; thereby 'ding proof that this system was revolving around the center ıass of itself and a third body in a relatively long period of :.

'urther observations have been secured at intervals since ;ust, 1899, for the purpose of detecting the first evidence of ıge in velocity of the center of mass of the short-period em. Changes suspected in the latter half of 1900 have now become certain: the velocity of the center of mass of the binai system has varied from — 11.8^{km} in 1899 to about — 13.5^{km} the present time.

The period of the binary system, 3^d 23^h 14^m.3, deduced 1899, seems to satisfy recent observations perfectly.

IV.—THE RADIAL VELOCITY OF *α PERSEI.*

Mr. H. F. NEWALL, from observations made at Cambrid England, has announced [*The Observatory*, December, 19 that the velocity of *α Persei* is variable. His results lie betw — 4 and + 8^{km} per second, and were secured in the years 18 and 1900.

The following table contains all the Mills spectrograph obs vations of this star, with the time-intervals between success dates:—

Date.			Velocity.	Interval.
1896	November	11	— 2.0^{km}	
				1 day
	November	12	— 1.8	
				68
1897	January	19	— 3.5	
				539
1898	July	12	— 2.1	
				440
1899	September	25	— 1.5	
				447
1900	December	16	— 2	
				10
	December	26	— 2	
				4
	December	30	— 2	
				0
	December	30	— 3	
				14
1901	January	13	— 2	

These ten observations, made in six different years, exhibit range of only two kilometers. Since this is about the us range for such stars, due largely to changes in the observe personal habits in measuring the plates, we may say that th observations afford no evidence of variable velocity.

V.—THE RADIAL VELOCITY OF *θ URSÆ MAJORIS.*

Observations of this star at Pulkowa in the years 1894 a 1896 by Dr. BELOPOLSKY gave results ranging from + 1^{km} + 22^{km} per second; and it was announced as a spectrosco binary with period of from five to seven days. [*Astr. Na* No. 3549; *Astroph. Jour.*, XI, 383.] Results obtained by same observer in February and March, 1899, ranging fr + 7^{km} to + 19^{km}, were considered by him to furnish no evide of variable velocity during those months [*Astr. Nach.*, No. 360

Mills spectrograph observations, as published below, do
icate variable velocity.

Date.			Velocity.
1897	November	16	+ 15 ± km
1899	December	18	+ 16
	December	24	+ 15
	December	27	+ 14
1900	January	30	+ 14
1901	January	27	+ 14

: VARIABLE VELOCITY OF δ *ORIONIS* IN THE LINE OF SIGHT.

variable velocity of this star was discovered by M. H. NDRES from observations made with the great Meudon ır. This star is not on the programme for the Mills spectro- as its lines are very broad and unsuitable for accurate ement. However, Mr. WRIGHT has secured three obser- , as below, which confirm M. DESLANDRES' discovery.

Date.			Velocity.
1900	August	12	+ 3 km
	August	21	+ 51
	September	17	— 69

VATIONS OF THE SATELLITES OF *URANUS* IN 1900 AND 1901.

present great south declination of *Uranus* makes observa- f its faint satellites difficult in northern observatories even he best conditions, and worthless when the conditions are On this account a comparatively small number of meas- pecially of the two inner satellites, *Ariel* and *Umbriel*, was l during the last two oppositions of the planet. For of hts when the 36-inch telescope was available to me, I used work only those on which the satellite measured could be ntinuously during the time of observation, and on which ge of *Uranus* was sufficiently steady and well-defined to accurate bisections to be made with the micrometer-wire. detailed observations with notes on the relative bright- the satellites and a comparison of the observed positions ose derived from NEWCOMB'S Tables (Washington Obser- for 1873—Appendix I) are published as *Bulletin* No. 7 of k Observatory.

Umbriel was usually the most difficult of the satellites to see, and *Titania* the easiest. But on several nights *Ariel* could not be seen steadily, though *Umbriel* was measured satisfactorily.

The residuals derived from the comparison with NEWCOMB'S tables indicate that the satellites are slightly in advance of their predicted places, and that their orbits are a little smaller than those given by NEWCOMB.

The average residuals are:—

Ariel	+ 2°.2	− 0″.29
Umbriel	+ 1 .2	− 0 .16
Titania	+ 1 .45	− 0 .18
Oberon	+ 0 .7	− 0 .13

On the assumption that these quantities represent the error of the tables, I computed the probable error of a single observation of each satellite with the following result:—

Ariel	± 1°.2	± 0″.16
Umbriel	± 1 .1	± 0 .18
Titania	± 0 .6	± 0 .20
Oberon	± 0 .3	± 0 .18

NEWCOMB'S tables are based upon observations made with the 26-inch refractor of the U. S. Naval Observatory in 1874 and 1875. That they represent observations made a quarter of a century later as closely as is indicated by the residuals here given is sufficient commentary upon the skill and care with which they were constructed, and upon the accuracy of the observations on which they were based.

R. G. AITKEN.

OBSERVATIONS OF THE SPECTROSCOPIC BINARY *CAPELLA*.*

The first-magnitude star *Capella* was discovered to be a spectroscopic double star, early in August, 1899, from an examination of the plates of its spectrum secured with the Mills spectograph in 1896. Announcement of the fact was made to the Astronomical and Astrophysical Society of America at the meeting of September 7, 1899, and in the *Astrophysical Journal* for October, 1899.

Independent discovery of its binary character was made by Mr. H. F. NEWALL, of Cambridge, England, in November, 1899, and announced in the *Monthly Notices Royal Astronomical Society* for November.

* From Lick Observatory Bulletin, No. 6.

The spectra of the two components are distinguishable on most of the plates, the exceptions being those taken when the radial velocities of the two were nearly equal, producing a superposition of the two sets of lines. The spectrum of the principal star is of the solar type, whereas that of the secondary is intermediate between the solar and Sirian types.

The velocities of the principal component, as observed with the Mills spectrograph, are given by the following table:—

No.	Date. Greenwich M. T.	Velocity. Kms.	No.	Date. Greenwich M. T.	Velocity. Kms.
1	1896, Sept. 1.036	+36.4 C.	17	1899, Nov. 6.026	+54.8 C.
2	17.005	53.8 C.	18	27.952	43.2 W.
3	Oct. 4.003	50.3 C.	19	27.966	44.0 W.
4	6.029	46.9 C.	20	Dec. 3 720	35.2 C.
5	Nov. 12.865	4.2 C.	21	18.648	12.6 W.
			22	24.882	7.7 W.
6	1899, Aug. 12.999	48.3 C.			
7	27.052	26 1 C.	23	1900, Jan. 10.649	7.7 C.
8	Sept. 12.950	5.7 W.	24	21.740	21.7 W.
9	20.006	5.1 W.	25	Feb. 11.724	50.0 W.
10	20.919	3 5 W.	26	26.726	55.2 W.
11	20 933	5.4 W.	27	26.740	54.8 C.
12	25.909	6.6 C.	28	Aug. 2.012	3.6 C.
13	Oct. 3.988	14.8 C.	29	Sept. 19.944	55.5 C.
14	16.912	32.9 C.	30	24.950	53.9 C.
15	16.929	32.0 C.	31	27.005	53.7 C.
16	31.892	52 0 C.			

[Measures of the plates by CAMPBELL and WRIGHT are indicated by C. and W. respectively.]

The presence of the second component's spectrum interferes considerably with the measures of that of the first component, and the probable error of a single observation, ± 0.50 kilometer, deduced by Dr. REESE, is as small as could be expected. Measures of the speed of the second component are somewhat uncertain, but an estimated range of from — 3 to + 63 kilometers will not be far from the truth. The masses of the two components are therefore as 1.26 to 1.

The solar-type component is estimated to be half a magnitude brighter, photographically, than the bluer component. In the visual portion of the spectrum the solar component is probably at least a whole magnitude the brighter of the two.

Inasmuch as the spectroscope takes account of the component of speed in the line of sight, and is powerless to measure the component at right angles to the line of sight, the spectroscopic orbit is determinate in form, but indeterminate in size. The inclination of the orbit-plane remains unknown. The minimum orbit capable of satisfying the observed velocities corresponds to the case of the orbit-plane passing through the observer. In this case, the maximum distance between the two components would be about 85,000,000 kilometers; and, if ELKIN'S value of the parallax of *Capella*, 0".08, is correct, the angular separation of the components, as viewed from the solar system, would approximate 0".045 when passing through the nodes. Such an orbit would give rise to eclipses every fifty-two days. No variations in the brightness of *Capella* having been observed, it is said to assume that the orbit-plane makes an appreciable angle with the line of sight.

In the case of a great number of orbit-planes distributed fortuitously, the most probable value of the angle between the normal to the orbit-plane and the line of sight would be 60°. The corresponding angular separation of the components at the nodal points would be about 0".052. In case this angle should be 30°, the corresponding separation would be 0".09.

The question as to whether *Capella* could be observed as an ordinary double star early arose. It was most carefully examined with the 36-inch refractor on several occasions in 1900 and 1901 by Messrs. HUSSEY and AITKEN, and on one occasion by Mr. PERRINE; but neither duplicity nor elongation could be detected. Their observations were made under the most favorable conditions, and we may conclude that the angular separation of the components is less than 0".06.

A discussion of the probable masses of the components with reference to the mass of our Sun seems to be futile, on account of the impossibility of harmonizing the best available data for the parallax and brightness of *Capella*, the brightness of our Sun and the angular separation of the components.

1901, July 25. W. W. CAMPBELL.

A DETERMINATION OF THE ORBIT OF *CAPELLA*.

[ABSTRACT.]*

The computation is based on the thirty-one observations of the velocity in the line of sight of the solar-type component given in the preceding note. The method of computing the orbit is exactly that given by LEHMANN-FILHÉS (*A. N.* 3242), except that in the equations of condition the correction to the velocity

* The complete paper is printed in Lick Observatory *Bulletin*, No. 6.

of the center of mass of the system is introduced as a sixth unknown, with coefficient unity. The period, 104.1 days, was assumed as best agreeing with the observations, and the observed velocities were plotted as functions of the time interval after the next preceding minimum, assuming September 18.9, 1899, as a time of minimum. A smooth curve was drawn through the points so obtained, and by means of a planimeter the line representing the velocity of the center of mass of the system was drawn so as to inclose equal areas with the portions of the curve above it and below it. The other requisite quantities were then obtained in the way shown in the article already cited. From the set of provisional elements thus found, an ephemeris was computed after first combining certain of the observations in pairs so as to form in all twenty-seven normal places. From the residuals derived by comparing the observations with this ephemeris, equations of condition were set up and solved in the usual manner.

The probable error of a single observation was found to be $\pm$ 0.50 kilometers per second. The final values of the elements with their probable errors are:—

$\mu = 0.060403$	± 0.000014 radians
$\omega = 117^\circ.3$	$\pm 18^\circ.3$
$T = -17.4$ days	± 5.3 days, the actual date being Sept. 1.5, 1899
$e = +0.0164$	± 0.0055
$K = 25.76$	± 0.12
$U = 104.022$ days	± 0.024 days
$a \sin i = 36,847,900$ kilometers	
$V = +30.173$	± 0.104 kilometers per second

The great uncertainty in the values of ω and T is due to the fact that the orbit is nearly circular. The probable errors of the other quantities are small in view of the difficulty in measuring the spectrum of this star.

It will be recalled that VOGEL and SCHEINER photographed the spectrum of this star from October 6, 1888, to September 15, 1889, but failed to detect its binary character, their spectroscope being apparently incapable of resolving its composite spectrum. By carrying back the period of 104.022 days to 1888 and 1889, their observations can be compared with the orbit. It is found that their plate, number 19, was taken at a time when the relative velocity of the two components was about zero. This plate the marked "excellent." Four other plates, numbered respectivel 14, 15, 18, and 67, and marked "very good," "good," etc were taken at times when the velocity of the solar componen relative to the center of mass was nine kilometers or less. On plate, number 95, is marked as rather poor except for a good H line, although the velocity of the solar component relative to th center of mass was only six kilometers. With this exception a plates marked "verwaschen," "uncertain," etc., were take when the relative velocity of the two components was very larg and therefore the two spectra were very much separated, so a to cause a blurring of the composite spectrum.

JULY 25, 1901. H. M. REESE.

SCIENTIFIC VISITORS TO THE LICK OBSERVATORY.

The Lick Observatory was favored with visits from the follow ing persons, returning to their homes from the Sumatra eclip stations:—

F. W. DYSON, Esq., F. R. S., Chief Assistant in the Roy Observatory, Greenwich.

Dr. W. T. HUMPHREYS, of the Department of Physics, Un versity of Virginia.

Dr. GILBERT, of the Department of Physics, Lehigh Unive sity.

Professor Dr. A. A. NIJLAND, Director of the Observator Utrecht, Holland.

Dr. J. H. WILTERDINK, Astronomer in the Royal Observ tory, Leiden, Holland.

Professor and Mrs. D. P. TODD, of Amherst College.

W. W. C.

ASTRONOMICAL TELEGRAMS.

(Translation.)

CAMBRIDGE, MASS., Aug. 6, 1901.

To Lick Observatory: (Received Aug. 7, 9 P.M.)

WILSON, at Northfield, Minn., telegraphs that he observe ENCKE'S periodic comet on its return on August 5.8924 G. M. ' in R. A. $6^h\ 2^m\ 2^s.8$; Decl. $+31°\ 42'\ 30''$.

(Signed) E. C. PICKERING.

[A cablegram from Kiel, giving a sweeping ephemeris ENCKE'S comet computed by THONBERG was received at th Lick Observatory on August 5, 1901, at 4 P. M.]

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in carrying out the work of this department. Communications of general interest will be gladly received, and may be sent to SIDNEY D. TOWNLEY, 2023 Bancroft Way, Berkeley, California.

Mr. FREDERICK H. SEARES, who, while Instructor in Astronomy in the University of California, took an active part in the conduct of the affairs of the Astronomical Society of the Pacific, has been elected Professor of Astronomy in the University of the State of Missouri. Professor SEARES has been studying in Berlin and Paris during the past two years.

On September 5th the students in astronomy at the University of California enjoyed an "astronomical talk" by Professor DAVID P. TODD, of Amherst College, who is passing through California on his return from the Island of Singkip, where the last solar eclipse was observed. Professor TODD reports that clouds unfortunately interfered, and that his programme of work was therefore only partially carried out.

"Some Advances made in Astronomical Science during the Ninteenth Century," is the title of an address, printed in *Science* for July 5th, recently delivered at the University of Pennsylvania by Professor C. L. DOOLITTLE.

A new astronomical observatory with increased equipment, including the equatorial telescope which formerly belonged to the late Judge NAPP, of New Jersey, is being erected at Lincoln University, Pa. This will be used mainly for purposes of instruction under the directorship of Professor WALTER L. WRIGHT, Jr., who has for a number of years been in charge of the department of mathematics at that institution.—*Science, August 9th.*

The Council of the Astronomische Gesellschaft has undertaken the preparation of a new Catalogue of Variable Stars and has delegated the conduct of the work to a committee consisting of Professors DUNÉR, HARTWIG, MÜLLER, and OUDEMANS. The committee request observers of variable stars who have considerable unprinted series of observations which would be useful in the correction of elements either to publish them soon or to

communicate them to the member of the committee in ch[arge]
(Professor G. MÜLLER, Potsdam Observatory).

The committee also announces that it will from the pre[sent]
time undertake the definitive notation of newly discovered v[ari]ables as soon as their light-fluctuations are certainly ascertain[ed].
A list will shortly be published of the names of variables fou[nd]
in recent years which have heretofore remained unnamed.

Science for August 9th contains a review of the *Astronomischer Jahresbericht*, by Professor GEORGE C. COMSTOCK, from which we quote the following introductory historical statement:—

"This series of annual volumes, whose somewhat cumbrous title is officially abbreviated to the symbol *A J B*, owes its inception to its editor, Professor WISLICENUS, who in September, 1898, submitted to the Astronomische Gesellschaft a well-elaborated plan for a year-book that should serve both as an annual summary of current astronomical literature and as a bibliography sufficiently complete for the use of students and other investigators. The proposal was favorably received by the society, which not only gave its official sanction and pecuniary support to the undertaking, but also appointed a committee, consisting of Professors SEELIGER, BRUNS, and MÜLLER, to confer with the editor as to the contents of the future volumes and the manner of their arrangement."

ENCKE'S periodic comet was well seen at this observatory at $3^h\ 45^m$ this morning, August 14, 1901. It was then in α, $6^h\ 58^m$ and in $+\delta$, $30^\circ\ 34'$, with rapid motion toward the southeast. The comet was quite large, faint, diffuse, and presented a minute trace or condensation of light, supposed to be a nucleus. The light was white, sky clear, air steady, and the observation was considered satisfactory. EDGAR L. LARKIN, Director.

MOUNT LOWE OBSERVATORY, CAL.,
August 14, 1901.

In a work entitled "Ueber die Ursache der Nordlichter" the Swedish chemist S. ARRHENIUS advances a theory in explanation of the phenomena of the Aurora Borealis and of the solar repulsion of comets. The work is reviewed at length by A. W. AUGUR in the June number of the *Astrophysical Journal*.

The explanation has for a basis the electromagnetic theory of CLERK MAXWELL who proved that in a medium in which electromagnetic or light-waves are propagated, a pressure is produced in the direction of propagation which, at any point, is numerically equal to the total energy per unit volume.

Solar repulsion of the tails of comets, and the apparent ejection of matter from the Sun to form the corona and solar projections, have long puzzled scientists as seeming exceptions of the law of gravitation. KEPLER attempted the first explanation, basing his hypothesis on the emission theory of light, supposing that the matter might be repelled by the impact of the corpuscles. NEWTON accounted for the phenomenon by supposing such a difference in the density of the surrounding medium as causes the ascension of hot air and smoke. EULER, in the eighteenth century, held that light-waves, which he supposed to consist of longitudinal vibrations in the ether, were competent to produce repulsion. This view was so severely criticised that it was soon abandoned. Nevertheless, if MAXWELL'S electromagnetic theory of light be accepted, it appears that EULER was, in the main, right.

A calculation of the radiant energy of the Sun is given, the result being equal to 592×10^{-10} gram-centimeters at the distance of the Earth. At the surface of the Sun this is much greater, being equal to 2.75×10^{-3} grams per square centimeter. This pressure is always away from the Sun, and since the weight of a body at the Sun is 27.47 times its weight at the Earth, a body of unit density and a cube of one centimeter, suspended so that its lower surface were perpendicular to the Sun's rays, would lose about one ten-thousandth part of its weight. If the body were more or less transparent a deduction would have to be made for the light transmitted; but if the body were a perfect reflector the effect would be doubled; so perhaps computations based on the assumption that all radiations are absorbed will be near the truth.

An assumption is then made of the size of the particles which could be acted on by the Sun's rays to effect a total loss of weight. According to BREDICHIN, the matter composing the tails of comets is, at perihelion, repelled from the Sun with a force of 1.5 to 18.5 times its weight. Assuming that the tails of comets are composed of gaseous hydrocarbons whose density could hardly exceed 0.8, the computed diameter of the particles to be thus repelled would lie between 0.1μ and 1.25μ. Such particles would be larger than simple molecules, as micro-organisms of a diameter not greater than 0.3μ have been observed, which, being of complicated organic molecules, are larger than the simple inorganic particles.

Upon this theory is based explanation of the origin and behavior of comets. As a comet approaches the Sun, there is developed on the side toward the Sun an extension of the coma. This is accounted for by supposing that the head of the comet is composed of solid or liquid hydrocarbons of relatively high boiling-point, which are vaporized under the intense heat of the Sun; while the particles are comparatively large they fall towards the Sun, but with their further dissipation they will be repelled and form part of the tail. If the nucleus is heterogeneous, particles of many sizes may be formed, which, by their varying degrees of repulsion, may give rise to several distinct tails, as in the comet of 1774.

A variation in size of the particles explains the fact that the repulsion of the tail is not always proportional to the inverse square of its distance from the Sun. Comets are more numerous and brighter in years when sun-spots are plentiful or the times when the solar activity was at a maximum. This means the repulsion of "cosmic dust" into space, which particles may aggregate till they again fall to the Sun in the form of comets. This "cosmic dust" may account for the phenomena of the solar corona and the Zodiacal Light.

It is almost certain that these particles would be highly electrified, and developing cathode and Rœntgen rays, would ionize the surrounding gases. The negative ions would form centers of condensation for the "cosmic dust," which, leaving the Sun and the positive ions behind, would pass outward into space. The sunny side of the Earth would receive a constant stream of negatively charged particles which would remain in the upper air. The atmosphere would be most strongly charged in the direct line between the Earth and the Sun, and in this region cathode rays might be developed. Under the action of the ultraviolet light, which would render the air conducting, the charges would be gradually conducted toward the less illuminated regions to the north and south.

This theory of the formation of cathode rays overcomes the objections raised to the statements of Dr. PAULSEN, who concluded they were the same as the Aurora Borealis, on account of their similarity in essential characteristics.

Since cathode rays tend to follow the lines of force in a magnetic field, the rays will, near the equator, lie in the upper air where the lines of force are parallel with the surface of the Earth.

At the poles, where the lines of force dip towards the Earth, the cathode rays in following, will reach denser strata of air, which produces the illumination of the Aurora.

Practically all the known facts concerning the Aurora harmonize with the theory that the light is produced by the cathode rays which arise from negatively electrified particles repelled from the Sun. The remarkable identity of the eleven-year periods of the Aurora and sun-spots, the annual, monthly, and daily variations in the number and intensity of the Aurora following closely the variations in the positions of the Sun, and the intensity of its light may all be much more satisfactorily explained by this theory than perhaps by any other.

The variability in light of *Eros* forms the subject-matter of Harvard College Observatory Circular No. 58, and in it Professor E. C. PICKERING reviews the theories advanced as an explanation of the variability.

If, as it seems probable, we assume that the variation is due to the rotation of the planet, we can, from measures of its light, determine the time of rotation and the direction in space of the axis of rotation.

Four corrections must be made to the observations: (1) for the velocity of light; (2) for the distance of the Sun and the Earth; (3) for phase; and (4) for the direction of the axis of rotation.

Of the two explanations advanced,—(1) that the variation is due to one side of the planet being darker than the other, and (2) that it is due to the rotation of two bodies,—Professor PICKERING seems to lean towards the latter. In the first case, the successive maxima would always have the same intensity, and would succeed each other at equal intervals, which would be equal to the period of revolution, and this is not true. In the second case, if the two bodies differed in diameter, the successive maxima and minima might have unequal intensities; and if the orbit were elliptical, the intervals between them would be alternately long and short. This seems to be the case with *Eros*.

On the other hand, if the variation in light is caused by two similar bodies alternately eclipsing each other, it is difficult to see how more than half of the light can be cut off in each case, and the minima be more than three quarters of a magnitude fainter than the maxima. It then becomes necessary to assume that the two bodies are of unequal brightness, that they are elongated, or that we have a single body, of the shape of a dumb-bell. Some observers have found the minima two magnitudes fainter than the maxima. To account for this, we should be obliged to assume that one axis of the body was six times as long as that at right angles to it. Observations show that the light of *Eros* is continually varying; while if the case were that of a simple eclipse, as in the stars of the *Algol* type, we should expect that it would retain its full brightness for a large portion of the time.

Photographs of *Eros* taken in 1893, 1894, and 1896, furnish material for determining the constants mentioned above. Those of 1893 and 1894, which were exposed an hour or more, and in which the planet trailed upon the plate, showed little variation in light. The plates taken in 1896 give more conclusive evidence of changes. In 1898, photometric measures were made, and they furnish an accurate determination of the times of maximum and minimum and of the range for that epoch.

Since July, 1900, a large number of photometric measurements have been made, but the results have not been analyzed. This is promised in a future "circular." On May 8th, Professor PICKERING announced that the variation in the light from the planet had become zero.

The first brief despatches announce that the attempt made by the expedition to Sumatra from the Massachusetts Institute of Technology to photograph the shadow-bands at the time of an eclipse was successful. A writer in *Engineering News* of August 1st thus describes the bands and the apparatus used.

Professor ALFRED E. BURTON, who is in charge of the Sumatra expedition, has associated with him GEORGE L. HOSMER, of the Engineering Department; Mr. HARRISON W. SMITH, of the Department of Physics, and Mr. G. H. MATTHES, a graduate of the institute, now in the U. S. Geological Survey. Before going abroad this party especially studied this shadow-band problem, and devised means for better recording them for later study.

Heretofore these bands have only been observed visually. These quivering bands of light and shade were noted upon the walls of buildings or on the white sand; and the first attempts at record were made by spreading a sheet on the ground upon which sticks were placed to show the direction of the shadows ınd their movements. A slight advance upon this method was :he use of long strips of canvas marked with black lines to facili- :ate visual measurements of the bands. Sticks painted in alter- ıate colors have also been employed, while an assistant sometimes ·an with the shadows, so as to furnish a comparative standard for :stimating their velocity. Methods of this kind were used by ?rofessor WILLIAM H. PICKERING, in observing at Granada, Spain, the eclipse of August 29, 1896.

But as these attempts at record are manifestly crude, all heories regarding these shadows, based upon them, are more or ess speculative. Professor PICKERING reported that some of he bands were six feet long, and some of unknown length; that ome moved at the rate of only six miles an hour, and others at he rate of an express train, and some moved in an undulatory ashion, with the speed of the wind.

He believed that the bands were due to disturbances of the ıtmosphere, and were not due to the shadow of the Moon, which noves at the rate of a mile a second. He assumed that every tar cast its shadow-bands too faint to be seen, and demonstrated his by producing artificial bands on the observatory wall at Cambridge by an electric light located three-quarters of a mile ıway.

During the eclipse of January 1, 1889, Mr. WINSLOW UPTON observed at Willows, Cal., shadow-bands an inch in width and hree or four inches apart, and apparently stationary; but an :ndeavor to photograph them in the ordinary way under favor- ıble circumstances proved a failure. In recent eclipses long lark bands separated by light spaces have been seen, more or ess distinctly, moving rapidly on the ground or on the sides of buildings just before and after totality. At the eclipse of May 28, 1900, an attempt to photograph the bands on a screen failed.

The method used at the last eclipse was planned by Mr. HARRISON W. SMITH before leaving Boston. The new plan is o actually expose a sensitive photographic plate to the bands hemselves, letting the bands fall upon it; that is, in place of :ndeavoring to photograph the bands as they appear on a screen. t was proposed to use a shutter of the form of the Thornton- Picard focal plane shutter. In the preliminary experiments two ordinary curtain-rollers were fixed at the end of a light wooden rame, with an opaque curtain stretched over the rollers, to be olled up on one roller, and, when released, wound up rapidly on the other by means of a spring. This curtain contained a slot and was stretched directly above a sensitive plate. When th curtain was released, the slot was drawn rapidly across the plate which was then exposed to whatever light happened to be fallin on the apparatus. If the intensity of light in Sumatra varie sufficiently from point to point to produce visible bands, it woul appear that the bands ought to be recorded by this apparatus o the plate. Again, by having two slots in the curtain, one trave ing across the plate just after the other, the velocity of the banc could be determined, since the bands on opposite halves of th plate would not join, but would appear displaced relatively t their velocity and that of the moving curtain.

Two sets of apparatus placed at an angle of ninety degree would record the bands, whatever their direction might be; an if the records obtained in Sumatra are as intelligible as the pla of the apparatus would presume, astronomers will have for th first time accurate data for scientific study of this particularl puzzling phenomenon.

The meeting of the Board of Directors of the Astronomic Society of the Pacific, and the meeting of the Society itse which were to be held at the Lick Observatory on Septemb 7th, were adjourned, without transacting business, for lack of quorum.

Obituary Notices.

Truman Henry Safford, for many years Professor of stronomy at Williams College, died at Newark, June 12th. rom a short account of his life, published in *Science*, July 5th, by rofessor Harold Jacoby, the following extracts are taken:—

"Born January 6, 1836, at Royalton, Vt., he showed already in his ırly boyhood the extraordinary arithmetical powers which distinguished m through life; for he could at all times multiply mentally very large ımbers, knew off-hand the multiplication-table to 1,000, and most of ıe logarithmic tables to three figures. At fourteen he is said to have ılculated a cometary orbit, and he graduated from Harvard at eighteen. or some years he was observer at that University under Bond, and for short time was acting director. In 1865 he took charge of the Chicago bservatory, where he began his serious work, the observation of one f the Astronomische Gesellschaft zones. But his work was cut short nd his position lost through the great Chicago fire. He then entered Vheeler's astronomical survey in the far West, and worked during everal years for the Government scientific bureaus of Washington. It as not until 1876 that he finally settled down for life as Professor of ıstronomy in Williams College, Williamstown, Mass.

"Here was done his principal work, which related especially to star-ositions and star-catalogues. He made an elaborate discussion of all xisting observations of the stars most suitable for determining geo-raphical latitudes of the United States. This resulted in a catalogue of ,018 stars, which was published by the Engineer's Department, U. S. ırmy. Later, he made a similar catalogue of 612 stars, and upon it has een based the new boundary between the United States and Mexico. his was published in the report of the Mexican Boundary Commission, Vashington, 1898. Safford built at Williamstown a meridian observa-ıry, which is a model of its class. In it he installed a Repsold circle, ith which he made extensive observations of the close polar stars. He ked these stars especially, and the unusually lengthy numerical calcula-ons connected with them did not frighten him. He needed no observ-ıg list, as his memory never failed to give him the instrumental setting ır each of his beloved polars in every possible position of his instru-ıent. These polar observations were collected and published by him in ıe "Williams College Catalogue of North Polar Stars." . . .

"More striking, perhaps, was his confident prediction, in 1861, of the ıinute unseen companion of the bright star *Sirius*. Basing laborious alculations on the tiny irregularities in existing observations, he was ble to show just where the little *comes* must be. And there it was found ı January, 1862, by Alvan Clark, of Cambridgeport, Mass., while he as testing the 18-inch glass mounted at Evanston, Ill.

"Safford was a frequent contributor to astronomical and educa-ional publications, and a member of many learned bodies. The Royal ıstronomical Society of London honored him with an election as

associate, in 1866, when he was but thirty years of age. Great as were his abilities in astronomy, he was yet at his best as a teacher. Those who came under his influence at Williamstown can bear witness to this; his ablest pupils profited most from his stored learning, and some from among them are laboring for astronomy to-day."

GEORGE K. LAWTON.—In the unexpected death of GEORGE K. LAWTON, of the U. S. Naval Observatory, a young astronomer of great promise has passed away. The loss to American astronomy can be appreciated as yet only by those who had the good fortune to know him intimately. He was born October 20, 1873, and died at Washington, July 25, 1901, after a brief illness of twelve days, of typhoid fever; and was thus less than twenty-eight years of age. Under the guidance of his father, Professor U. W. LAWTON, of Jackson, Michigan, he had enjoyed from childhood excellent educational advantages, and in 1895 graduated in classics at the University of Michigan, where he also pursued advanced astronomical studies under Professor ASAPH HALL, Jr., at the Detroit Observatory. He then spent a year in postgraduate study at the University of Chicago, where the writer had the honor to be one of his teachers. He showed distinguished abilities in the study of celestial mechanics and of higher mathematics. He was afterwards attached to the Observatory of Yale University for a short time, occupied mainly with work on meteors; and then came to the Naval Observatory as one of the regular computers. In 1897 he took the degree of M. A. at the University of Michigan.

While attached to this observatory he participated in all the transit-circle observations of the past five years, much of which has recently appeared in the *Publications of the U. S. Naval Observatory* (Vol. I, New Series). Last year he bore an important part in the observations of the total eclipse of the Sun, at Pinehurst, North Carolina. More recently he took the leading part in the reductions and revision of the *Eros* observations of this observatory, and has been occupied partly with equatorial work. Only a month ago he was permanently assigned to the 26-inch equatorial, and had entered upon researches of great promise.

On account of his extreme modesty, and the arrearages of our publications, his scientific reputation at the time of his death was in no way commensurate with his merits. Yet he was already a member of the American Association for the Advancement of Science, and last year participated in the meeting of the Astronomical and Astrophysical Society of America.

His mind was developed in admirable symmetry and harmony, and his scholarship almost as good in Latin and Greek and general literature as in modern science. He had that happy faculty of cool, quiet judgment, combined with good-nature, which made him adequate to any occasion. Besides possessing scientific and literary talents of a high order, he was of a very high-minded and noble disposition, universally beloved by his associates. Unseen by men, he continually did many acts of benevolence, and bestowed gracious remembrances which add to the charm of life and make us realize that the high types written of long ago have not wholly passed away. He was an active member of St. Thomas's Church in this city, of the Brotherhood of St. Andrew, and of the Alumni Association of the University of Michigan. During his residence here of five years, he became fairly well known in the city, more by the reputation of his high character than by any very extensive mingling with the people. When the writer had to send the saddest of messages to his grief-stricken family, the telegraph operator, who knew him only by reputation, was nearly overcome, and said, "That good man is not long for this world." In all my experience I have never met quite so modest, so noble, and so loving a character.

The sudden death of Mr. LAWTON, almost at the very beginning of what promised to be a brilliant career, has cast a deep gloom over the entire observatory. He was indeed the noblest of the noble, and his place can never be filled.

WASHINGTON, D. C., July 27, 1901. T. J. J. SEE.

ERNST AUGUST LAMP.—On May 10, 1901, Professor LAMP, Astronomer of the German Boundary Commission, died in German East Africa. Professor LAMP was born in Kopperpahl, near Kiel, April 4, 1850. He studied in the universities of Kiel, Berlin, and Göttingen, taking his degree at the last named place in 1874. From 1874 to 1877, he was employed at the Geodetic Institute in Berlin; from 1877 to 1883, second observer at the Kiel Observatory; from 1883 to 1897, first observer in the same institution. Upon leaving the Kiel Observatory in 1897, he was connected for some time with the Royal Geodetic Institute at Potsdam, and later with the Boundary Commission mentioned above.

Professor LAMP's chief astronomical work was upon comets. His numerous observations and orbits have been published in the

Astronomische Nachrichten (volumes 87 to 141). In volumes VII and IX of the *Publications of the Kiel Observatory*, he has published extensive investigations of the orbits of the Brorsen Comet and Comet 1891 I. Besides the comet work, Professor LAMP did considerable with the meridian-circle and considerable of a geodetic nature.

ADOLF CHRISTIAN WILHELM SCHUR, Director of the Royal Observatory, Göttingen, died July 1st of this year. He was born April 15, 1846, at Altona, and early became interested in astronomy through a near relative, A. C. PETERSON, then Director of the Observatory at Altona. SCHUR studied at the Universities of Kiel and Göttingen, taking his degree at the latter place in 1868. He then went to Berlin and, after working for a time under AUWERS and FOERSTER, became an assistant in the Geodetic Institute, where he remained until 1873, when he was called to a position at the Strassburg Observatory. Here he remained until 1886, when he was called to Göttingen to succeed KLINKERFUES in the chair of Practical Astronomy.

While at Strassburg SCHUR was engaged in various investigations with the instruments of the observatory, chiefly with the Fraunhofer heliometer, which was used in the Transit of *Venus* expedition of 1874, of which SCHUR was a member. One of the chief investigations with this instrument was a series of measures on the system of *Jupiter*, which led to an exact determination of the mass of *Jupiter*.

At Göttingen also, SCHUR'S work was chiefly with the heliometer, measurements of the *Præsepe* and of the clusters *h* and χ *Persei* absorbing a large part of his time.

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NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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LICK OBSERVATORY — CROCKER ECLIPSE STATION, PADANG, SUMATRA.

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THE LICK OBSERVATORY-CROCKER EXPEDITION TO OBSERVE THE TOTAL SOLAR ECLIPSE OF 1901, MAY 17-18.

BY C. D. PERRINE.

In continuation of the expeditions dispatched by the Lick Observatory for the observation of total solar eclipses, one was sent to Sumatra to observe the eclipse of May 17-18, 1901. These expeditions have been made possible by the generosity of private citizens of California who have borne the expenses incident to such undertakings. Inaugurated by Colonel CHARLES F. CROCKER, Regent of the University of California and member of the Committee on the Lick Observatory, they have been continued since his death by his brother, Mr. WILLIAM H. CROCKER, of San Francisco.

Owing to the temporary difficulty of forming future plans after the death of Director KEELER, the organization of the expedition was delayed and the preparations were hurried. While some of the observations planned for were the same as those undertaken at former eclipses, and for which the apparatus needed but slight changes to adapt it to the present eclipse, several investigations required the construction of entirely new instruments. The four telescopes for the intramercurial planet search, two spectrographs, and a polarigraph were constructed and tested in less than a month. The entire staff of the Observatory took up the work, so that, notwithstanding the stormy and unfavorable weather, the equipment was packed and ready for shipment in time for the steamer leaving San Francisco on February 19th for Hongkong.

A rather large equipment of instruments was taken, as previous experience had shown the feasibility of obtaining observers to operate them at or near the station.

The expedition left San Francisco on February 19th, on the steamship "Nippon Maru," of the Toyo Kisen Kaisha. At Honolulu we found the United States transport "Sheridan," and there exchanged greetings with the members of the United States Naval Observatory party.

It was hoped that connection could be made with the North-German Lloyd steamer leaving Hongkong on March 20th for Singapore, but owing to almost continuous heavy weather and head winds as far as Yokohama, we were two days late at the latter port, and reached Hongkong only in time to see the coveted steamer leaving the dock.

Fortunately, however, the "China," a steamer of the Austrian Lloyd Steamship Company, was found to be leaving in two days. After a good run of five days, Singapore was reached on March 27th. The steamer of the Koninklijke Paketvaart-Maatschappij left on the 29th for Batavia. Although having a full cargo of freight and a heavy passenger-list, the agents made room for us, placing the instruments in the second-class cabins. Batavia was reached on March 31st. The through steamer for Europe of the Stoomvaart-Maatschappij Nederland was leaving Batavia on April 3d, stopping at Padang for through passengers and freight only. Again the steamship company was most accommodating, giving us passage on a crowded steamer, and placing the eclipse freight in the baggage-room. Thus we arrived in Emmahaven on April 5th, at daylight, fully ten days earlier than was expected when we left California. Almost the first sight to greet our eyes in the harbor at Emmahaven was the United States steamer "General Alava," with the astronomers of the United States Naval Observatory party on board, they having arrived from Manila the evening before.

From Hongkong to Padang it was noticed that often when the sky near the zenith was fairly clear of clouds they seemed to hover about the land, particularly the mountains, and rain was often seen to fall there. Observations at Padang for several days after arrival showed that the clouds gathered about the mountain-tops and spread thence towards the plains and the ocean. The early mornings were often quite clear, but almost invariably clouds began to gather over the mountains by nine or ten o'clock, and rain was of frequent occurrence in the after-noons. The location, therefore, which seemed to promise best was one as far as possible from any high mountains. Padang is situated in the southern end of a long plain, three or four miles wide, bounded on the west by the ocean, on the south by steep hills, and on the east by the abrupt mountains of the Barisan range, rising to altitudes of 3,000 to 5,000 feet. The probabilities of a clear sky seemed to be as good in Padang as anywhere on the main island. There appeared to be a slight advantage in favor of a station on one of the small low islands forming a chain five to ten miles off the coast, but as the sky was often thick with haze when not cloudy the advantage of such a location was not considered sufficient to counterbalance its disadvantages. It was, therefore, decided to remain in Padang, and a site for the station was chosen on the abandoned racecourse in the northern portion of the city. Its approximate position was—

Longitude $6^h\ 41^m\ 20^s$ East of Greenwich.
Latitude $0°\ 56'$ South.

The programme of observations was entirely photographic, and was as follows:—

1st. Photographs of the prominences and inner corona with the 5-inch Clark lens of 40 feet focal length, after the method devised by Professor SCHAEBERLE.

2d. Photographs of the corona with the Floyd telescope of 5 inches aperture and 70 ± inches focal length.

3d. Photographs of the outer corona with the Pierson* (Dallmeyer) camera of 6 inches aperture and 32.6 inches focal length.

4th. Duplicate photographs of the region near the Sun for the detection of any small planets with orbits interior to that of *Mercury*. These negatives were to be secured with four telescopes of 3 inches aperture and 11 feet 4 inches focal length.

5th. One photograph of the spectrum of the corona, using one light prism, and having the slit east and west across the Sun's center.

6th. One photograph of the spectrum of the corona with a spectrograph similar to the preceding, but having the slit directed north and south, about 2′ east of the Sun's east limb. These two spectrographs were intended to record any Fraunhofer lines in the corona.

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* This Dallmeyer portrait-lens belongs to Hon. W. M. PIERSON, of San Francisco, and has been very kindly loaned by him for a number of eclipse expeditions.

7th. Photographs of the corona with a camera of 20.75 inches focal length, having a double-image prism of one inch aperture placed in front of it. Photographs were to be secured of both images, the position-angle of the prism being changed during the eclipse so as to have its principal plane make angles of 0°, 22½°, 45°, 67½°, and 90°, respectively, with the Sun's equator. Such photographs should show polarization if it exists in a given plane to any considerable proportion.

A large shed of bamboo, covered with palm thatch (atap), was constructed first, serving as a work-shed and as a shelter for partly-mounted instruments. As showers were frequent and came with little or no warning, and as a protection against the sun also, shelters were constructed first and instruments mounted under them afterward. Many of the rains were very heavy — too heavy to be turned by canvas. As the residents of that moist country say, it rains in "strings,"— and the "strings" are frequently almost ropes. After three days of one heavy storm it was noticed that the hollow bamboo fence-posts (just erected) surrounding the camp were overflowing; the deepest cavity in these was ten inches. How much more fell in the three days I do not know.

The tropics seem to be made of bamboo tied together with rattan and protected from the rains by "atap." It was only necessary to buy a small cartload or so of bamboo and atap and a bunch of rattan; out of these materials the expert Malay carpenters constructed everything. Sills, joists, rafters, all parts of framing, were of bamboo tied together with rattan. If a stake was wanted, the bamboo pile furnished it. If a fence was to be built, the same bamboo pile was resorted to, the posts were made of the full-sized thicker ends, the "boards" being long split sections passed through slots cut in the posts. The gate was of bamboo, even to the hinges and catch.

Only a slight elevation was available upon which to build the tower required to support the lens and tube of the 40-foot telescope, and as no excavation was possible, it was necessary to build a structure 36 feet high. Two towers were used after the plan adopted by Professor CAMPBELL at the Indian eclipse, and used also in Georgia. The inner tower was a mere skeleton of bamboo to support the lens. Around this was constructed another tower of bamboo, and covered with thatch to protect the lens-support from the wind. Upon this outer tower rested the frame of gas-pipe containing the canvas telescope-tube.

FORTY-FOOT CAMERA AND POLAR AXIS.

The ground was composed of sand and clay, saturated with water, and vibrations were easily communicated. The passage of a light cart along the street one hundred yards away caused such vibrations that sextant observations were impossible. It was feared that this unsteadiness of the ground would affect the images in the 40-foot telescope. In fact, the star-trails taken for focus did show irregularities, but as an examination of the Sun's image in transit and some experiments showed no vibration in the telescope, these irregularities could only be explained by atmospheric disturbances at night. It was noticed that the stars twinkled very markedly on all but a few nights.

Owing to the uncertainties of the climate, and the desirability of having shelter from the sun as well as from the rain, the roofs of the shelters for the intramercurial telescopes and the polar axis were hinged at the sides so that they could be opened or closed in a few seconds.

All of the smaller instruments, five in number, were mounted on one long polar axis, being driven by one clock. Although the exposures were of widely varying lengths, by using black cloths for exposing-caps and having all exposures, as far as possible, end at the same time, no difficulty whatever was experienced from jarring.

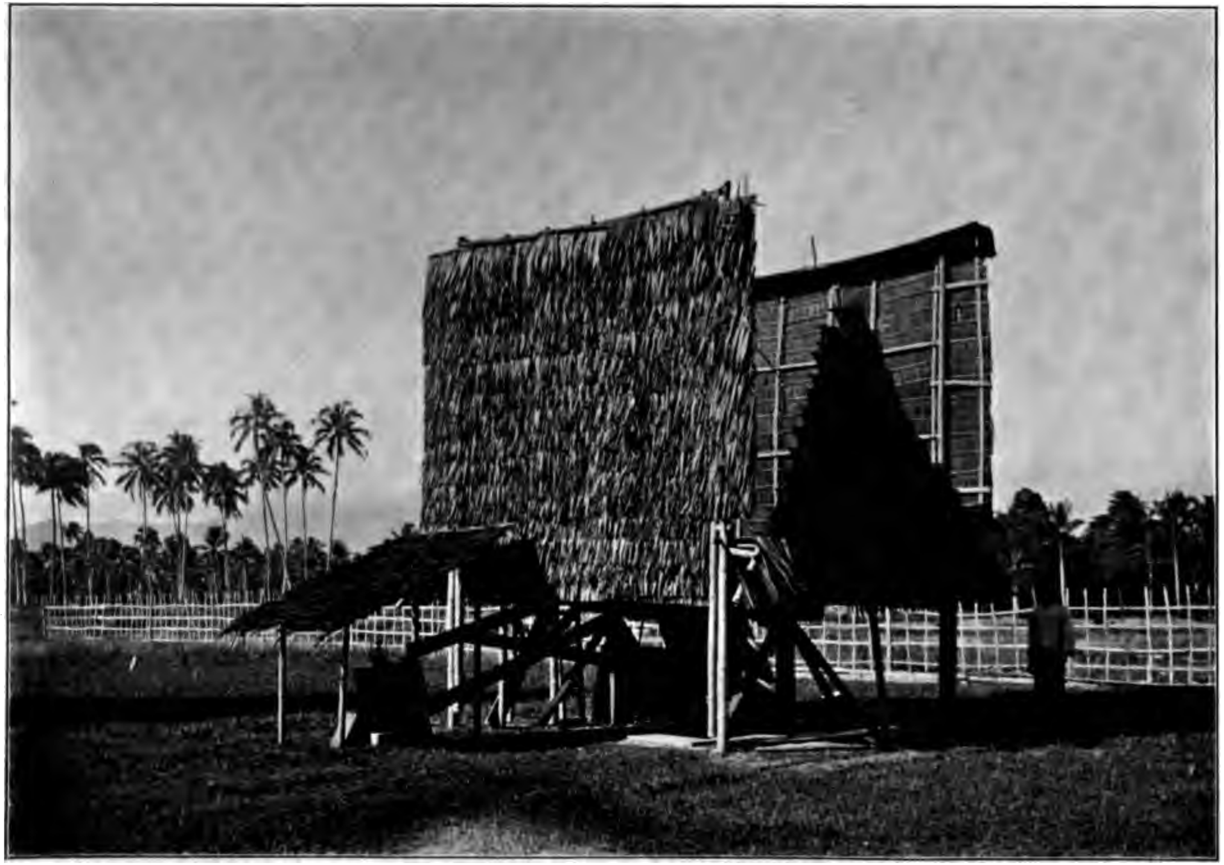
The tubes of the intramercurial planet telescopes, four in number, were made of sheet steel, five inches square at the objective end and increasing to the size of a 14 × 17 plate-holder. Each of the lenses was first mounted in a brass flange of good width. These were in turn secured by three sets of pushing and pulling screws to a brass casting screwed into the end of the steel tubes. This arrangement permitted of the final adjustment for focus and collimation with the same set of screws. The telescopes were mounted in two pairs, each pair consisting of two telescopes exactly parallel, thus permitting two simultaneous exposures of the same region of sky. The two pairs were so placed that their axes made an angle of 20° with each other, and were rigidly fastened together. This combination was then mounted on an auxiliary axis, which permitted the longer axes of the plates to be moved in the direction of the Sun's equator. As the 14 × 17 plates used covered a field of 5° 54′ by 7° 8′, two changes of position sufficed to cover a region 18° on either side of the Sun along his equator and nearly 6° in width. The most probable orbit of such a body would place it well within the region covered by such a series of photographs. The tubes and auxiliary axis were mounted in a large wooden box, and this in turn was mounted equatorially and driven by a clock operating at the end of a sector of ten feet radius. With the exception of the steel tubes, the mounting was constructed at the Lick Observatory by our skilled workmen. Though necessarily cumbersome, it performed admirably, being very rigid and coming to rest almost immediately after disturbance.

The performance of the single achromatic lenses * used for this work was very satisfactory. Good images were secured over a 14 × 17 plate with the exception of the corners, and even here the distortion was not serious.

All the instruments were mounted and practically in adjustment by May 12th. The intervening time was devoted to drilling the assistants, to checking the adjustments of the many instruments, and to arranging the final details.

A dark-room had been improvised, for night use only, in a small native bamboo house on the grounds. Preliminary experiments in photographic work had been made in the photographic department of the "Staatsspoorweg," which had been placed at our disposal by Mr. DELPRAT, Chief Executive of these government railways. The day temperatures generally ranged from 85° to 90° F., the air being almost saturated. The night temperatures were but little below 80°, with a heavy precipitation of dew. In continued rainy or cloudy weather the temperature fell to from 70° to 75° during the night and early morning. Photographic manipulations under such conditions were not easy, but with some changes in the formula, and by a liberal use of ice and alum, good results were secured with *fresh* plates. Plates exposed for any considerable time to the action of the atmosphere deteriorated rapidly, one of the most marked changes being a great loss of sensitiveness. It is not sufficient that the pasteboard boxes containing the plates shall be sealed; the only real protection is to have them hermetically sealed in metal boxes. The plates for eclipse work had been sent in two lots, one containing those needed for the focusing of the instruments, the

* These lenses were designed by Professor W. H. PICKERING, and used by him at the 1900 eclipse. Two of those used in Sumatra were kindly loaned by Professor E. C. PICKERING, Director of Harvard College Observatory. The other two were of the same design, made by ALVAN CLARK & SONS for the Lick Observatory, through the kindness of Professor PICKERING.



INTRAMERCURIAL TELESCOPES (SHELTER OPEN).

other lot for use on eclipse-day. Each lot was soldered up tightly in a tin box, that containing the plates for the eclipse not being opened until the night before, when all the holders were loaded. Plates which I carried along in my trunk, for viewing purposes, had so deteriorated, even before reaching Padang, as to be useless.

Offers of assistance in making the observations had been tendered liberally as soon as it was known that such help would be needed. Fifteen persons were invited to assist. Rehearsals of the programme to be carried out at the eclipse were begun four days before. In this way all gained familiarity with the necessary motions, and the programme was carried out with entire confidence. The observers and their stations were as follows:—

Time was counted at the chronometer and the necessary orders given (all in Dutch) by Mr. DELPRAT.

Forty-foot telescope: Messrs. R. H. CURTISS and F. BOUMAN.

Intramercurial telescopes: The exposures were made by Mr. NIEUWENHUYS. The plates were changed by Messrs. CLETON, GULDENAAR, D'HANENS, and PERRINE, the latter making the necessary changes of position of the telescopes.

Floyd telescope: The exposures were made by 1st Lieutenant P. L. DE GAAY FORTMAN, and the plates changed by 2d Lieutenant WARNSINCK.

Pierson (Dallmeyer) camera: The exposures were made by Mr. VON DER STRAETEN, and the plates changed by Mr. VON LEEUWEN BOONKAMP.

Radial slit spectrograph: This instrument was operated by Mrs. DE GAAY FORTMAN.

Tangential slit spectrograph: This spectrograph was operated by Mr. JUNIUS.

Polarigraph: The exposures were made by 2d Lieutenant SIEBURGH, and the plates changed by Mr. J. KEMPENS.

Shadow bands were observed by Mr. LAGERWEY.

The day before the eclipse had been one of clouds and rain, as was the day following. Eclipse-day dawned not altogether auspiciously, but with some promise. Light clouds covered the entire sky, but seemed to be growing thinner, and occasionally glimpses of blue sky could be seen. The Sun's disc was almost entirely free from clouds at first contact, although the rest of the sky was generally covered. The sky did not improve, however, as the eclipse progressed. At no time during totality was the sky about the Sun clear, light cirrus clouds and haze covering the entire sky, with the exception of a perfectly clear area near the northern horizon.

During the morning there had been some wind from the north, west, and south, but as the obscuration increased it began to die down. Canvas wind-screens had been placed about the polar axis and the intramercurial telescopes during the morning, but were not needed, as there was a perfect calm during totality. This dying-out of the wind I have noticed also at the two previous eclipses which I have observed.

The usual phenomena of light changes and cooling of the atmosphere were observed. No measures of light intensity were made, but a table of logarithms was placed where the light of the corona and surrounding sky shone fairly upon it and at mid-eclipse it was necessary to look closely to distinguish the figures. After the middle of totality the increase of light was quite marked, due partly, in all probability, to the increasing cloudiness. During the afternoon the sky overhead and to the west became entirely clear.

The entire programme was carried through successfully, although at that time there was scant hope of many results of value. No attempt was made to develop any plates in daytime, but during the following four nights the work was completed. It was an agreeable surprise to find that negatives of value had been secured with all the instruments.

Following is a list of the negatives secured, with the principal data relating to them, and a short description of the result on each:—

List of Negatives.

40-foot Camera.

No.	Size of Plate.	Kind of Plate.	Exposure.	REMARKS.
1	8 x 10	Carbutt B	½s	Good.
2	14 x 17	Seed 27	1	Good. Detail off E. limb well shown.
3	14 x 17	Seed 27	2	Good. Detail off E. limb well shown.
4	14 x 17	Seed 27	4	Good. Corona to 15′.
5	14 x 17	Seed 27	16	Good. Corona to 15′.
6	18 x 22	Seed 27	40	Good. Corona to 20′.
7	18 x 22	Seed 27	150	Good. E. streamer to fully 1⅓ diameters.
8	14 x 17	Seed 27	4	Good. But little corona.
9	14 x 17	Seed 27	25	Good. About the same extension as No. 3.
10	14 x 17	Seed 27	8	Good. Much less than Nos. 3 and 4.
11	14 x 17	Seed 27	1	Good.
12	8 x 10	Carbutt B	½	First flashes of returning sunlight.

Floyd 70-inch Camera.

1	5 x 7	Seed 27	½	Good. Streamers to 10′.
2	5 x 7	Seed 27	2	Good. Eastern extension to one diameter.
3	5 x 7	Seed 27	8	Good.
4	5 x 7	Seed 27	4	Good. Streamers to 25′.
5	5 x 7	Carbutt B	60	Good. Streamers to over a diameter.
6	5 x 7	Seed 27	20	Good. Extensions only 15′.
7	5 x 7	Seed 27	2	Good. Extensions only 5′.
8	5 x 7	Seed 27	½	Good.

Pierson (Dallmeyer).

1	8 x 10	Seed 27	½	Eastern streamers to one diameter.
2	8 x 10	Seed 27	2	Eastern streamers to one diameter.
3	8 x 10	Seed 27	8	Eastern streamers to one diameter.
4	8 x 10	Carbutt B	30	Over-exposed.
5	8 x 10	Seed 27	4	Slide not drawn.
6	8 x 10	Carbutt B	60	Over-exposed. Eastern streamer to 1¼ diameters.
7	8 x 10	Seed 27	20	Slide not drawn.
8	8 x 10	Seed 27	10	Corona to 20′.
9	8 x 10	Seed 27	2	Caught by returning sunlight.
10	8 x 10	Seed 27	½	Not exposed.

Intramercurial.

No.	Size of Plate.	Kind of Plate.	Exposure.	REMARKS.
A 1	14 x 17	Seed 27	90^s	28 stars.
B 1	14 x 17	Seed 27	90	Faintest = 8.8 visual magnitude.
C 1	14 x 17	Seed 27	90	37 stars. Faintest = 8.6 visual magnitude.
D 1	14 x 17	Seed 27	90	
A 2	14 x 17	Seed 27	90	27 stars.
B 2	14 x 17	Seed 27	90	Faintest = 8.8 visual magnitude.
C 2	14 x 17	Seed 27	90	No star images.
D 2	14 x 17	Seed 27	90	
A 3	14 x 17	Seed 27	75	No star images. Inner corona and *Mercury*
B 3	14 x 17	Seed 27	75	and *Venus* are distinct.
C 3	14 x 17	Seed 27	75	No star images.
D 3	14 x 17	Seed 27	75	

Spectrograph I (Slit Tangential).

No.	Size of Plate.	Kind of Plate.	Exposure.	REMARKS.
1	2⅛ x 3¼	Cramer Crown	320^s	Good.

Spectrograph II (Slit Radial).

1	2⅛ x 3¼	Cramer Crown	320^s	Good.

POLARIGRAPH.

No.	Setting.	Size of Plate.	Kind of Plate.	Expo-sure.	REMARKS.
1	0°	3¼ x 4¼	Cramer Crown	1ˢ	Negative good.
2	0	3¼ x 4¼	Cramer Crown	10	Slide not drawn.
3	22½	3¼ x 4¼	Cramer Crown	1	Negative good.
4	22½	3¼ x 4¼	Cramer Crown	10	Negative good.
5	45	3¼ x 4¼	Cramer Crown	1	Negative good.
6	45	3¼ x 4¼	Cramer Crown	10	Negative good.
7	67½	3¼ x 4¼	Cramer Crown	1	Negative good.
8	67½	3¼ x 4¼	Cramer Crown	10	Negative good.
9	90	3¼ x 4¼	Cramer Crown	1	Negative good.
10	90	3¼ x 4¼	Cramer Crown	10	Negative good.

The negatives secured with the 40-foot telescope show the extreme inner corona and the prominences as well, probably, as if the sky had been clear. The two long exposures of 40 and 150 seconds, respectively, show detail in the middle corona, and the latter shows the streamers of the eastern equatorial extension to one and one-third diameters from the limb. Some of the detail at this distance is lost, however. A number of small prominences, exhibiting considerable detail, are shown on the east limb. One of these prominences, in position-angle 115°, is covered by a series of marked "hoods," or envelopes. There are other structures of this nature, but much less pronounced.

One of the most interesting features of the corona was an area in the northeastern quadrant where clouds of coronal matter were piled up as if by an explosion on the Sun's surface. That it is true coronal matter is indicated by the tangential spectrograph which had its slit across this region. The disturbed area appeared to have its origin in position-angle 65°, near a small compact prominence, and masses of matter are shown radiating from it in almost all directions. A long thread-like prominence to the south appears to emanate from this same region. The whole area resembles the condensations seen in photographs of the *Orion* and other irregular nebulæ. All the appearances point strongly to a direct connection with an eruption in some part of the Sun's surface, thus linking the corona closely with other solar phenomena, all requiring a single explanation. So far as I am aware, no such appearance as this in the corona proper has been observed at any previous eclipse.

The inner corona is well shown on the smaller-scale negatives obtained with the FLOYD telescope, but beyond one and one-quarter diameters the corona was so faint as to be lost in the louds and haze. This is also the case with the negatives btained with the PIERSON camera; in fact, with this instrument he long exposures recorded the images of the clouds. Owing to ne inadequacy of the half-tone process to bring out fine details, lustrations of the corona are omitted for the present.

The clouds interfered most with the intramercurial planet earch. The plates taken of three regions out of the six show 92 ars, the faintest being from 8.6 to 8.8 magnitude, but so far no ar-images have been found on the plates of the other three egions. A careful preliminary examination of the plates was nade at the station in Sumatra, but no suspicious object detected. A thorough search of all the plates will be made later, and it is oped that some stars may be found on all of the plates, thus nabling some conclusion to be drawn as to the maximum brightess which any such body or bodies can have.

The earlier exposures with the polarigraph show the equatorial xtensions of the corona to one diameter from the limb; toward he end of totality only about one quarter of a diameter is shown, wing to the increased cloudiness. A large percentage of polariation is indicated in the light of the corona beyond 10′ from the mb, and the later exposures point to a small percentage of olarization in the inner corona also. This is true of all positionngles, including the regions containing the polar streamers. The double-image prism used in this instrument separated the wo images about 1¼ degrees. These were extremely convenient or comparison with each other, and the method of detecting olarization effects was practically a differential one.

The two spectrographs (as well as the polarigraph) were degned and prepared for use by Director CAMPBELL and Assistant stronomer W. H. WRIGHT. The results obtained show both istruments to be very efficient for the purpose of recording ark lines in the spectrum of the corona. In a clear sky the pectrum of the inner corona would have been over-exposed.

Radial Slit Spectrograph.—The slit of this instrument was laced east and west across the Sun's center. The negative overs the region from λ 490 to λ 360 $\pm$, the spectrum extending n either side of the Moon's disc to over a diameter. The image f a prominence on the east limb of the Sun covered the slit, roducing very bright over-exposed *H* and *K* calcium lines, as vell as the other characteristic prominence lines. On either side of the Moon's disc is a band of continuous spectrum about 8′ in vidth without any trace whatever of dark lines. Outside of this

band at least 35 Fraunhofer lines can be counted between *H*
and *H*, extending out to the limits of the spectrum. Beyon
$H\beta$ and *H*, in either direction, there is but little trace of th
spectrum of the outer corona. A longer exposure would doubtles
have shown all the Fraunhofer lines observable with the sli
width and dispersion used. Bright *H* and *K* lines of marke
strength extend entirely across the Moon's disc, and to a distanc
of 40′ east of the Sun's limb, but show only feebly on the we
side of the Sun. They are symmetrical with reference to th
image of a prominence on the east limb, indicating a diffusion
our atmosphere of calcium radiations from this and other neig
boring prominences. Comparisons with a sky spectrogra
secured with the same instrument show that the coronal and sk
spectra are sensibly the same in the blue and violet regions.

Tangential Slit Spectrograph.— The slit was placed north an
south across the corona about 2′ east of the Sun's east limb. Th
negative shows practically the same range of spectrum as the pr
ceding one, with a width of rather over a solar diameter.

The *H* and *K* lines are bright and quite strong, the latt
having the greater intensity. No doubt these are due to calciu
radiations diffused in our atmosphere. No other bright lines a
to be seen. Although the continuous spectrum is strong, no
of the details are obliterated. Several stronger bands exte
longitudinally through the spectrum, which are due in
probability to the brighter condensations in the corona prope
Many Fraunhofer lines are visible, especially between $H\gamma$ a
K, and can be traced across the full width of the spectrum. Th
are less distinct where they cross the dark belts mentioned abov
The disturbed area of the corona, already referred to, fell acro
the slit of this instrument. This spectrogram was also compar
with a sky spectrogram, as in the previous case, and the san
agreement of the lines was noted.

A consideration of all the facts shows that the clouds have n
affected these results nor their interpretation.

Professor CAMPBELL has examined these spectrograms a
confirms the above results.

It should be noted that the spectroscopic observations made
the India eclipse of 1898 by Professor CAMPBELL also showed
trace of dark lines in the inner corona. These spectrogra
extended only to a distance of 2′.5 from the limb, being obtain
with high dispersion.

The preceding spectroscopic and polariscopic observations seem to point to a very definite explanation of the general constitution of the Sun's corona. Both methods of investigation show that the light of the outer corona is in great measure reflected sunlight, whereas the spectrograph shows the light from the inner corona to emanate principally from incandescent matter. These facts, taken in connection with the varying appearance of the corona, suggest as the most probable explanation that very finely divided matter is ejected from the surface of the Sun with great velocity, giving rise to the streamers and extensions observed. This matter may or may not be solid when it first leaves the Sun, but observation indicates that it is incandescent, and probably largely solid, when it first becomes visible above the layer of chromosphere. While in a state of incandescence its inherent light would in all probability be so great as to mask the light which must be reflected from the solar surface; but a point would be reached in its outward journey where it would become cool enough for the reflected light to become observable. Actual radial motion has not been observed in true coronal matter, but appearances point far more strongly to great movement than to a state of comparative rest.

The well-known bright lines observed on many occasions in the corona indicate, also, an irregular but comparatively thin gaseous envelope about the Sun. The quantity of light contained in the bright-line spectrum, however, is very small in comparison with that composing the continuous spectrum; and it is probable that the gaseous envelope does not appreciably affect the ordinary photographs of the corona.

The explanation suggested above, deduced through a different train of reasoning, from an entirely distinct set of facts, is in accord with the conclusion reached by Professor SCHAEBERLE from a study of the forms of the coronal streamers shown in his large scale photographs of the 1893 eclipse, that these streamers are composed of matter ejected from the Sun with great velocity.

The sky was unfavorable for Shadow-Band observations. Mr. LAGERWEY, however, detected faint bands at the beginning of the eclipse. These bands had wavy outlines at first, becoming almost straight toward the end of their apparition. The direction of the wave front was north 60° east and south 60° west, the waves moving in a direction at right angles to the wave front.

Times of Contacts.

The first three contacts were observed by me, as follows:—

	h.	m.	s.	
I	22	45	30.9	mean time of station.
II	0	18	52.3	
III	0	25	1.3 ± 1s	

Observed duration of totality, $6^m\ 9^s.0$.

The following are the times of the contacts for the station, computed from the data given in the American Ephemeris:—

	d.	h.	m.	s.	
Beginning of eclipse,	May 17	22	45	16.1	mean time of station.
Beginning of totality,	May 18	0	18	49.9	
End of totality, . .	May 18	0	24	56.8	
End of eclipse, . .	May 18	1	57	25.5	

Computed duration of totality, $6^m\ 6^s.9$.

Contact I was observed with the sextant, and is probably 2^s or 3^s later than geometrical contact. Contacts II and III were observed without optical aid. Contacts I and II were timed directly from the chronometer; contact III by means of the counts of the timekeeper, and is subject to a possible uncertainty of a second. As soon as possible after totality the counts were compared directly with the chronometer. The corrections to the chronometer were determined from sextant observations of the Sun.

The time observation secured after the eclipse indicated a considerable change of rate of the chronometer subsequent to the observation of the same morning. About ten minutes before the beginning of totality the chronometer was removed from the shelter, where it had remained undisturbed on a pier, in order to permit the timekeeper to have a view of the eclipse, and replaced in its original position shortly after totality. In determining the chronometer corrections at the time of the contacts it has been assumed that the change of rate occurred with the change of position of the chronometer.

The Great Southern Comet.

On May 4th a telegram was received from Professor Skinner announcing that a brilliant comet had been observed by Mr. Dinwiddie at Solok, in the western sky, just after sunset of the previous evening. The evening of May 4th was cloudy Padang, but the evening of May 5th was clear, and the com was seen low in the west against a very bright sky. Sextant observations were secured of its position, using the nearest available stars. As the sky darkened it became a very conspicuous object. It had a brilliant nucleus, and a tail 6° to 8° in length. The Pierson camera was mounted on the following day and directed to the place of the comet. Owing to the brightness of the sky and to the lack of means for following the comet, only short exposures were attempted. Four negatives were secured on May 6th, as follows:—

	Duration of exposure.	Length of tail.
No. 2_2	1^m	3°
4_2	3	3½
1_4	7	4
1	$0^m\ 30^s$	

The last plate contained no image, owing to the haze and proximity of the comet to the horizon.

The principal tail is composed of two slightly curved and nearly parallel streamers. The second and third negatives show a very faint streamer to the south, making an angle of 35° with the axis of the principal tail.

Clouds near the western horizon prevented any further observations or photographs, although the instruments were left in readiness until it became necessary to adjust them for the eclipse.

Mr. RALPH H. CURTISS, formerly assistant in the Students' Observatory, University of California, was appointed assistant in the Lick Observatory from February 15th, and accompanied the expedition, helping throughout in the work of preparing the station and in the observations.

A most cordial welcome was extended to eclipse observers by the officials and citizens of Padang, and I am largely indebted to them for the results secured. Especial thanks are due to His Excellency, Governor JOEKES for introductions to heads of departments and for his interest in the welfare and safety of the expedition at all times; to Kolonel H. F. C. VAN BIJLEVELT, commander of the army, who detailed a number of his officers to take part in the observations; to Major MULLER, of the general staff, N. I. Army, for advice as to the meteorological conditions and the choice of a station, as well as for many practical suggestions; to Assistant Resident HARTOGH HEISS, head of the police department of Padang, who not only made arrangements for the location for the station and obtained watchmen, but in his official capacity had the safety of the camp as his immediate care. On the day of the eclipse a body of twenty special policemen, with an equal number of employees from the railway, formed a cordon about the camp.

Mr. TH. F. A. DELPRAT, as chief executive of the railways, not only furnished free transportation for observers and apparatus over the railroads, but placed a fully equipped photographic dark-room and the facilities of the very extensive shops and stores at our disposal, detailed skilled workmen for specially important work, and at all times was ready to give advice and cordial help.

Mr. F. BOUMAN, chief of the construction department of the railways, with a wide acquaintance of the natives, practically superintended the construction of all the shelters and buildings required. We were thus relieved of many of the trials and extortions incident to dealings with the Malays by foreigners.

Mr. C. G. VETH, United States Consul at Padang, extended many courtesies to the eclipse observers, and was ready at all times to aid them. After the eclipse and just before the departure of the U. S. S. "General Alava," with the U. S. Government party of astronomers aboard, a banquet was given by Consul VETH in the ship's honor, to which all the astronomers were invited. It was a great surprise to hear the English language so generally spoken. A most enjoyable time and one long to be remembered was the result.

Social courtesies were freely extended by the residents of Padang, and served to enliven our busy sojourn there.

Those who took part in the work of observation were: Heer TH. F. A. DELPRAT, 1st Leutenant der genie P. L. DE GAAY FORTMAN, 2d Leutenant der Infanterie W. H. WARNSINCK, 2d Leutenant der Infanterie E. SIEBURGH, Mevrouw DE GAAY FORTMAN, Heer J. KEMPENS, Heer F. BOUMAN, Heer VAN LEEUWEN BOONKAMP, Heer VON DER STRATEN, Heer JUNIUS, Heer CLIFTON, Heer NIEUWENHUYS, Heer GULDENAAR, Heer D'HANENS, Heer LAGERWEY.

The greatest enthusiasm was manifested by all in the preliminary rehearsals as well as in the observations on eclipse day.

Favors were shown to the expedition in all possible ways from Mt. Hamilton to Padang, every one being not only willing but anxious to aid. Among these especial mention should made of Mr. ROBERT BRUCE, of the firm of Balfour, Guthrie

Co., of San Francisco; the Toyo Kisen Kaisha; the Occidental and Oriental Steamship Company; the Pacific Mail Steamship Company; the officers of the S. S. "Nippon Maru"; Mr. AUBREY FAIR, of Hong Kong; Mr. A. I. Ross and Mr. T. SCOTT of the firm of GUTHRIE& Co., Singapore; the agents and officers of the "Koninklijke Paketvaart-Maatschappij" and "Stoomvaart Maatschappij Nederland"; the representatives of the firm of J. DAENDELS & Co., in Singapore, Batavia, and Padang; the officers of the Hong Kong and Shanghai Bank, in San Francisco and Batavia, and the Java Bank, in Padang.

The natives were much aroused at the advent of so many astronomers, and the preparations for an event in which they had at first no faith whatever. Some of the keenest of their religious leaders, however, saw an opportunity, and shortly before the eclipse began to prophesy and to take much credit to themselves. The advent of the comet a fortnight before the eclipse and an epidemic about the same time in the native Kampong, from which many died, excited the more superstitious ones, and a rumor was brought to me that our camp was to be demolished. Whether we were in any particular danger or not will probably never be known, but there was anxiety in the police department until all was over. Our stay ended without an interruption and without any loss or damage to the instruments.

At the suggestion of Professor TODD, the various telegraph companies offered to transmit a message from Mauritius to the observers at Padang, giving them an hour or more in advance, the benefit of observations at the former point. A letter was sent to Padang, addressed to eclipse observers, by General Manager TAYLOR of the Eastern Extension Australasia and China Telegraph Company, Limited, at Singapore, notifying them of the arrangements made by the different lines for the transmission of this message. This letter was delivered by the postal authorities to me, and I at once notified all observers in Sumatra, within my knowledge, of its contents. Arrangements were made with the telegraph office in Padang for the prompt distribution of this message, which, however, failed to arrive.

After the eclipse was over, and the instruments all packed for shipment, a few days were spent in the interior of this very interesting but little-known island, visiting the peculiar native markets, climbing one of the active volcanoes, and seeing the Malays at

The lowlands of these tropical islands are hot, humid, and uncomfortable, but the higher lands have a most delightful temperature. At altitudes of 3,000 to 4,000 feet the temperature was that of a perfect early summer day of the temperate zones, very warm at midday, if clear, but pleasant at night,— cool enough for a light bed-cover, but without any chilling winds. The humidity at all altitudes is very near the saturation point, which, together with the warmth, causes a most luxuriant vegetation everywhere, a dense, impenetrable jungle where not kept down by constant work. Even the volcanic peaks which have been in eruption within a generation are again clothed with dense forests, covering all the scars. The rugged mountains, the towering volcanoes, some of them still active, the rice-paddies, the picturesque habitations of the natives, and the natives themselves, offer sights and adventures of surpassing interest, for this is indeed a world *contra* to all temperate climes.

Both going and returning we passed Krakatoa, in the Straits of Sunda, and it was not without a thrill that I looked upon that relic of a convulsion of nature which has perhaps no equal in history. Its appearance is proof enough of the tales of that outburst in 1883, when a superb volcanic cone half a mile in height was split asunder and one half lost in the sea; when all the contiguous islands and the near-by coasts of Java and Sumatra were devastated, their inhabitants and wealth utterly destroyed, and even the very face of nature changed; when ships were carried miles inland by the tidal wave over hills as high as their masts,— a convulsion which was thought to be the "crack of doom" by millions, and which was in reality such to tens of thousands. In April this giant was without any sign of life, but early in June smoke in considerable volumes could be seen rising from the almost perpendicular north face, the scar of the outburst of eighteen years ago.

It was a great pleasure to renew a number of acquaintances in Sumatra, and to meet for the first time many prominent astronomers from all parts of the world.

MT. HAMILTON, CALIFORNIA, 1901, November 11.

THE CAMP AT FORT DE KOCK.

THE U. S. NAVAL OBSERVATORY ECLIPSE EXPEDITION TO SUMATRA.

By Heber D. Curtis.

In pursuance of the liberal and progressive policy which provided for the observation of the eclipse of May, 1900, and for numerous extensive expeditions in the past, the Government late in 1900 appropriated the sum of $10,000 for an expedition to observe the total eclipse of May 18, 1901, in Sumatra. Owing to the exceedingly limited time, some of the special apparatus was necessarily constructed in great haste; but everything was ready by February 7th, a date which would give none too much time for the long journey and the equipment of the camps.

The Naval Observatory party proper numbered eleven members, namely: Professor A. N. Skinner, U. S N., Director; Professor W. S. Eichelberger, U. S. N., Assistant Astronomer, F. B. Littell, Mr. George Peters, Mr. L. E. Jewell, and Mr. W. W. Dinwiddie, of the Naval Observatory; Professor E. E. Barnard, of Yerkes Observatory; Dr. S. A. Mitchell, of Columbia University; and Dr. W. J. Humphreys and the writer, from the University of Virginia. Associated with the Naval Observatory on the trip was the Smithsonian party — Mr. C. G. Abbott, and his assistant, Mr. Paul A. Draper, of Washington. The distance to be traveled was nearly 14,000 miles by the route selected, the cost of which would have eaten very heavily into the available appropriations had not the party, through the courtesy of the Secretary of War and the Secretary of the Navy, been carried between San Francisco and Manila on a Government transport, and from Manila to Sumatra on the U. S. gunboat "General Alava."

San Francisco was left on February 16th, on the U. S. A. T. "Sheridan." The month-long sea-trip to Manila was pleasantly broken by a few days at Honolulu. Here we enjoyed the generous hospitality of the Hawaiian Philosophical Association. Many of our most pleasant memories of this garden-spot of the Pacific are due to their thoughtfulness and courtesy. The charms of the sail southward through the tropics will not soon be forgotten by any of the party. Some industrious astronomers busied themselves with computations. Frequent conferences of all the members were held to deliberate on the methods to be followed and results hoped for in Sumatra. Occasionally the land itself came up for discussion, and it was on one of these occasions that the reading from various books of travel of highly colored passages with regard to the serpents of the East Indies brought it about that these conferences were henceforth known to the laity as meetings of the "Snake Club." Thanks to several energetic young officers, other diversions were not wanting: two minstrel shows, several lectures and addresses, a dance, a tug-of-war and two spirited boxing tournaments among the soldiers varied the monotony, and all short-comings were condoned in the Mid-Pacific. Consul WILLIAMS, formerly stationed at Manila, but now at Singapore, was one of the passengers on the "Sheridan," and it was through his kindness that after reaching Manila we were taken about the bay in a Government launch over the track that DEWEY followed, while the Consul himself, who was on the bridge with DEWEY, told us many interesting details of the battle and pointed out the forlorn wrecks of the Spanish war-vessels.

The distance from Manila to Padang, Sumatra, is about 2,200 miles, and this portion of the trip occupied us ten days, which passed quickly enough in the warm and many-hued waters of the China and Java seas, past interminable island-continents that the geographies of our younger days represented as apparently of equal area to the Bahamas. Both going and returning through the Straits of Sunda, we passed within less than a mile of Krakatoa, where Verlaten and Lange islands still show the former extent of Krakatoa before its tremendous eruption.

On April 1st we enjoyed the astronomical novelty of a vertical Sun. On this day, at apparent noon, the Sun was only four minutes of arc from our zenith. I took a sextant and, bringing the Sun into coincidence with the horizon, swept the entire circle of the horizon without having Sun and horizon leave the field of the sextant. On the "Alava," also, we went through the time-honored ceremony of "crossing the line," an interesting and laughable rite of sailing-ship days now not frequently seen. Father and Mother Neptune and their motley crew "came aboard" to hold their royal equatorial court. A large tank of salt water was improvised from a canvas sea-anchor. All tyros on board must needs be presented, and several astronomers were among them. Neptune's doctor administered a soap pill; the ace was lathered with a vile mixture of red-lead and molasses;

THE 61½-FOOT TELESCOPE, WITH INTRAMERCURIAL CAMERA SHELTER IN BACKGROUND, SOLOK.

then followed a none too gentle shave with a two-foot wooden razor in the hands of Neptune's barber, a sudden twist by the stalwart jackies, and the victim made room for the next culprit by a beautiful back somersault into the salt-water tank.

It was nearly two months after leaving Washington that we finally cast anchor in the beautiful land-locked harbor of Emmahaven. The meteorological reports of the Dutch Government had been carefully studied, and Solok on the Padang plateau had already been selected as the chief station. After a few days spent in reconnoitering, the members were soon at the respective stations. Three stations were selected, well separated from each other and from the camps of other parties — Solok, Sawah Loento, and Fort de Kock. The first two are over one thousand and the last named nearly three thousand feet above sea-level, and are situated from fifty to eighty miles from Padang.

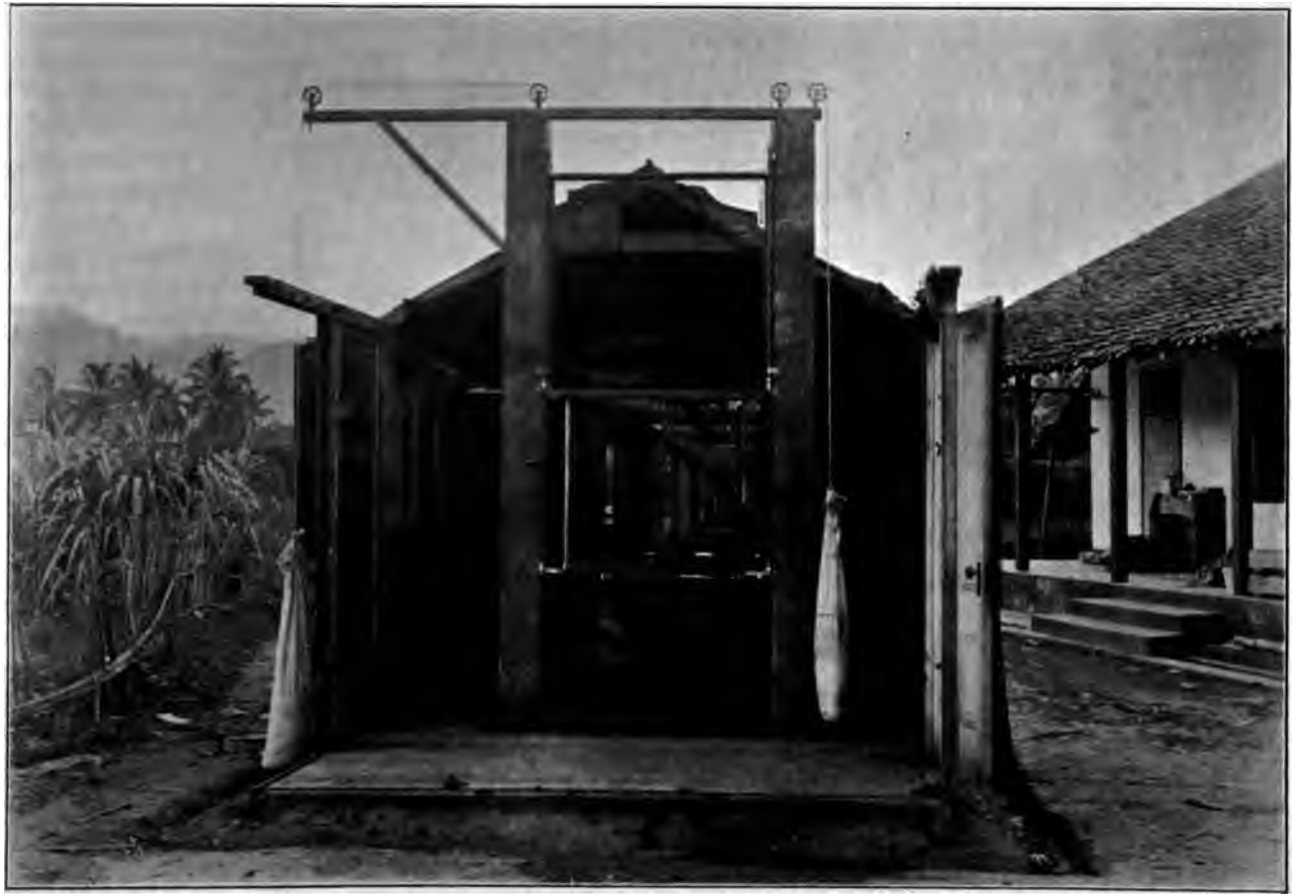
Solok was thirty-one miles from the central line; it was impracticable to go nearer the middle of the eclipse track, except on the coast, and stations were already chosen there by other parties. Alahan Pandjang, very near the central line, had been considered. It lies some thirty-five miles south of Solok, and is reached by an excellent road; but as our heavy equipment would have had to be transported there on the backs of coolies, it was decided that the increased advantages of this site would not warrant the time and the expense necessary to overcome the difficulties of placing a camp at this spot.

Fort de Kock, the northern station, was about seven miles south of the northern edge of the shadow, and the duration of the total phase at this point $2^m 40^s$. Here it was purposed to devote efforts particularly to the spectrum of the flash and inner corona and photographs of the inner corona with special reference to the polar streamers. Professor W. S. EICHELBERGER was in charge of this camp. Dr. W. J. HUMPHREYS here employed the 21½-foot concave grating belonging to the University of Virginia, while Mr. PETERS had charge of the forty-foot camera,— the lens, the property of the Naval Observatory, being the one used by Professor STONE in May, 1900, at Winsboro, N. C. In this instrument no plate-holders were used, but the plates placed and held against an adjustable frame placed at the focus.

Sawah Loento is a little town surrounded by mountains on all sides and is near the great government coal-mines. It is the southern terminus of the Sumatra Government Railroad, which was built primarily to bring the coal from these mines to the sea-coast. The coal is of very fair quality, and the mines are remarkable chiefly for the thickness of the deposits, one seam, I believe, having the unparalleled thickness of forty-two feet. The labor is entirely convict. The Dutch Government, with characteristic thrift, transports its Sumatra offenders to Java and the Javanese to Sumatra. These races hate one another so cordially that an escape of a convict is out of the question, and very little guarding is necessary. The curious little railroad was made to fit the country, not the country leveled and cut to make an easy road, and through the mountains engines of a composite type are used, on which supplementary gearing can be thrown into action on a heavy rack laid between the rails; the grades thus overcome are in several spots nearly 600 feet to the mile. It is an exceedingly picturesque road through the tropical growth of the mountains and the terraced rice-fields of the foot-hills; especially noteworthy is the beautiful Aneikloof gorge a few miles below the town of Padang Pandjang. The Naval Observatory station at Sawah Loento was located on the hillside about a mile from town and a few hundred feet above it, quite near the camp of the Massachusetts Institute of Technology. Dr. MITCHELL here had a large-grating spectroscope and a six-inch lens of 104 inches focal length. He was assisted by Mr. RENÉ GRANGER, of Cartersville, Ga., who came independently via London to give his services to the party.

The main station was located at the village of Solok (Long., 6^h 42^m 36^s E.; Lat., 0° $47'$ $17''$ S.). Here Professor SKINNER was particularly fortunate in securing for the eclipse camp a small fort which had been abandoned for about two years. It was about two hundred feet square and was surrounded by a wall, moat, and a *cheveau-de-frise* of wire tangle which effectually isolated the camp from the over-curious native. Along one side ran the large cement-floored barracks, which formed an excellent storehouse, and served also as sleeping quarters for four of the party, Hotel Talang, with a maximum capacity of six guests, being swamped by the influx of visitors. In one end of these barracks were located Mr. ABBOTT'S constant temperature room for the bolometric work. The fort was well drained, and the former powder magazine made an excellent dark-room.

At this station were located Professor BARNARD, with the



REAR VIEW OF THE 61½-FOOT CAMERA, SHOWING MECHANISM.

61½-foot camera; Mr. LITTELL, with a flat-grating spectrograph, and Mr. L. E. JEWELL, with a concave grating; Mr. DINWIDDIE, with a prismatic camera fitted with a large prism, loaned by the Smithsonian Institution; Dr. GILBERT, with a spectropolarigraph, loaned by Professor WOODS, of the University of Wisconsin; and the writer, in charge of a 7¾-inch lens of 114 inches focal length and a pair of large cameras mounted on a six inch equatorial.

Professor BARNARD's instrument received its light from a large coelostat provided with electrical control. The details of the tube and house are seen in the photographs. The electrical control worked perfectly. His method of exposing the plates may be seen in the cut of the interior of the photographic house. Two pillars of 8×8 timber were set firmly five feet in the ground; between these ran smoothly a counterpoised framework with suitable guides and stops. The upper compartment of the framework held a 40×40 plate-holder; the lower held 30×30. The larger holder remained in the sliding frame during the eclipse. The various 30×30 holders could be very quickly slipped in and removed after exposure. At the proper time the frame was pulled down so as to bring the image of the Sun in the center of the 40×40 plate, and after the exposure the frame was pushed up for the remaining exposures on the 30×30 plates. The 40×40 plate, the largest ever exposed for astronomical purposes, received an exposure of two minutes and a half. To prevent excessive over-exposure of the inner coronal regions, a screen of about the size of the Moon's image (nearly eight inches) was fastened to a long wire handle. The edges of this screen were covered with absorbent-cotton so as to be fluffy and ill-defined, and in use it was kept constantly in motion over the image of the Sun on the plate. All plates were backed, and those for the longer exposure on the smaller cameras and all those on the 104-inch and 114-inch telescopes, which were provided with visual lenses, were slow orthochromatic.

Mr. ABBOTT's intramercurial camera had numerous points of interest. A strong equatorial mounting carried four large cone-shaped tubes built up of small wooden rods so as to combine great rigidity with lightness. These were covered with light-proof rubber cloth. The four lenses were compound, of four inches aperture and eleven feet focal length. The same clock ran a large mirror on the telescope pier which threw the beam of light into the bolometric room, some ten feet distant. Each tube carried two 24×30 plates so arranged on hinged frames that one plate lay flat against the side of the tube while the other was in position. At the slipping of a catch the exposed plate was drawn up against the side of the tube by springs, and the second as quickly rotated into position, the entire operation occupying only a few seconds. The large shelter, covered within with black cloth, was a dark-room and camera combined, the exposures being made by a sliding curtain at the top.

Cut films were used on the various spectrographic plate-holders, bent to the proper radius against curved guides. The sliding plate-holders were equipped with suitable stops, so that successive films could be exposed with very little time lost in shifting.

Efficient assistance on the day of the eclipse was given by Mr. IRVING, a colporteur of the English Bible Society, who acted as our interpreter, and by Surgeon ODELL, Lieutenant CHASE, and nine sailors from the "General Alava." Accustomed to the discipline of a man-of-war, these intelligent and capable sailors took naturally to the drills preparatory to the eclipse and went through their programmes without a hitch. A break-circuit chronometer sent signals to a telegraphic sounder at each instrument; the minutes were struck on a locomotive-bell.

Only those who have been through similar experiences can realize the labor involved in setting up and adjusting the instruments of a large eclipse camp. Though we were agreeably disappointed to find in this portion of Sumatra a well-ordered colony, and not a tropical wild, there were many needs and emergencies in which we felt the limitations of the island very keenly. We found Dutch of comparatively little value, and learned Malay perforce, for the Dutch Government forbids the use of Dutch by the natives. Labor was cheap,—twenty to forty cents gold a day,—but of poor quality; for all work requiring more skill Chinese are employed. Watchmen were furnished us free by the Government,—two wizened hill-natives, who regularly slept through the night on our barrack porch. In this and other ways we came in contact with the "Heerendienst," or forced-labor system, of the Dutch Government, a much-criticised policy, but one which has certainly produced wonderful results in Java. Our greatest difficulty lay in the climate itself; for it was soon evident that our chances of a fair day were very poor. In such a land as Sumatra, where there are only two seasons,—a wet, and a wetter,—the difficulty lay in finding even gaps in the clouds for the necessary astronomical adjustments.

In all our difficulties, however, we found the Dutch officials ever helpful, kind, and obliging. It would be impossible to say too much of the kindness of the Colonial Government in this particular, its foresight in preparing for us in every way. Free transportation for all freight and baggage and an unlimited pass for all visiting astronomers were not the least of its favors. With every official, from Governor YOEKES to the humblest railroad employee, "Zoneklips" was an "open sesame."

Though it was foreseen that the chances were very poor, a few very good days in May had raised the hopes of all, and it would be useless to try to describe the feelings of the party at Solok as the 18th of May dawned with the sky covered with clouds. To the north a beautifully clear patch could be seen over Lake Sinkarak, too slowly approaching, for it reached us three hours after the eclipse. From computations made by Mr. LITTELL and the writer, the more important data for the eclipse at Solok were—

Contacts.		Solok Mean Time.
I.	May 17,	$22^h\ 47^m\ 31^s.8$
II.	May 18,	$0^h\ 21^m\ 20^s.8$
III.	May 18,	$0^h\ 27^m\ 12^s.7$
IV.	May 18,	$1^h\ 59^m\ 36^s.2$

Duration of total phase $5^m\ 51^s.9$.

Observations by Professor SKINNER with a three-inch telescope and of the first and fourth contacts with the six-inch by the writer agree in placing the observed eclipse about 12^s ahead of the computed time.

At the time of second contact the sky was covered with a layer of clouds not quite thick enough to conceal *Mercury* or *Venus* but sufficient to cut off all sight of the corona except a very narrow rim around the edge of the Moon, and it was with a feeling of the futility of further efforts that we went through our respective programmes. From about the third minute of totality, even the narrow rim of light disappeared; it was impossible to locate the eclipsed Sun visually, and plates taken at this time show nothing but fog. An interesting feature noticed by other observers under similar conditions was the quantity of light still present, reflected by the clouds from the illuminated land beyond the eclipse track. The lanterns which had been provided for a "dark" eclipse were entirely superfluous. It seemed to me personally to be lighter at Solok in mid-totality that at Thomaston in 1900 ten or twenty seconds before second contact,—this though the eclipse path was nearly one hundred and fifty miles wide and we were thirty-one miles from the central line. At Fort de Kock, on the other hand, where the sky was perfectly clear, lanterns were needed, although they were only seven miles from the edge of the shadow.

Thus even the hope of a veteran astronomer that we should be favored either with a clear sky or a pouring rain was not realized, for surely the most mournful part of an unsuccessful eclipse is the hopeless development of the great plates from which so much had been expected. Practically nothing of value was secured at Solok, equipped with what was perhaps the most powerful and representative array of instruments ever set up in a single camp. The prismatic camera secured a good film of the first flash, and some of the faster plates secured the rim of the inner corona, but hazy from drifting clouds. Mr. ABBOTT attempted no bolometric work; while quite a number of stars were made out on his plates taken in the first half of the eclipse with the intramercurial camera, it seems that the conditions prevailing at every camp where instruments of this sort were in operation leaves this problem still open, a question which it was hoped might be definitely settled at this unusually long eclipse.

Better results were secured at Sawah Loento by Dr. MITCHELL and Mr. GRANGER. The clouds here were much lighter, and the spectroscopic results in particular promise well.

Fort de Kock was the only camp on the island blessed with absolutely clear weather, and several excellent photographs were secured by Mr. PETERS and Dr. HUMPHREYS. All other camps had light clouds, though in many cases insufficient to ruin the spectroscopic and polariscopic results.

It took far less time to pull down than to fit up the camp, and several days were then very pleasantly spent in seeing the sights of this exceedingly interesting but little-visited corner of the globe. Several of the party ascended the active volcano Merapi, nine thousand feet high and only a few miles from Fort de Kock; the jungle climb to Pajo, near Solok, affords what is said to be one of the most beautiful views in the East Indies, and to all of us, the native, his customs and peculiarities, his picturesque, beauifully carved and decorated houses, formed a fascinating subject or observation and photography. This central portion of Sumara is thought to have been the original home of the Malay race. t is now well under Dutch control, and is covered with almost perfect roads, many of them dating from the English occupation of the island, roads which can not be paralleled in any State in he Union. At the north of the island, at Atjeh, the brave and capable Malays have been at continuous warfare with either the English or the Dutch for nearly one hundred years, and only thirty miles inland from Solok one finds the boundaries of the independent native states, to many of which no white man is admitted.

Aside from two weeks spent at Manila, our long trip home was without special interest, and we were very glad to disembark from the U. S. A. T. "Indiana" after nearly six months absence.

The camps of the various expeditions were quite well separated, from the Dutch and English on the coast near Painan to our own camp at Sawah Loento, while on the eastern coast of Sumatra Professor TODD occupied the island of Singkep. Over all this portion of the path the rule was cloudy weather, and it is to be regretted that in such an important eclipse as this one, especially in view of the tropical and exceedingly uncertain weather, the stations were not scattered even more widely. The Dutch were quite anxious that some nation should send its expedition to Borneo or Celebes. The conditions here would have been somewhat more difficult, but in no sense dangerous, and a station or two somewhere in this neglected portion of the shadow-path might have saved the day.

LEANDER MCCORMICK OBSERVATORY, Charlottesville, Va.

THE *LEONIDS*—GRAND DISPLAY OF METEORS AT LOWE OBSERVATORY.

BY EDGAR L. LARKIN.

The usual stream of *Leonids* was observed here from midnight until dawn November 15, 1901. The first meteor was seen at $11^h\ 53^m$ P.M. on the 14th, before the radiant rose above the peaks standing sentinel 1,800 feet east of the observatory. The altitude of the observatory is 3,420 feet, and the line of peaks from north to south varies in height above the building from 80 feet in the southeast to 1,340 feet in the northeast; so ***Regulus*** did did not rise until $0^h\ 49^m$ November 15th. When the radiant came up alongside of a cliff the rate of meteors was one per minute.

TABLE OF TIMES AND METEORS, NOVEMBER 15, 1901.

Times (P. S. T.)			Number of Meteors.
From $0^h\ 00^m$	to $1^h\ 00^m$		32
1 00	1 54	Cloud before *Leo*	27
1 54	2 53	Cloud before *Leo*	27
2 43	3		19
3 01	4		173
4	5		297
5	5 40		109
		Total,	657

Half, or probably slightly less, had trails of all degrees of brilliancy, and in length from 2° to 15°. Four fifths, by estimate, were white, a small number greenish-blue, a few tinged with red, while two were full red. Those leaving streamers were at high speed and seemingly at great altitude; others seemed near the Earth, the small ones not being visible more than half a second.

TABLE OF DIRECTIONS.

From	toward
From ε *Hydræ*	toward α *Columbæ.*
Præsepe	ε *Hydræ.*
ε *Hydræ*	*30 Monocerotis.*
Præsepe	γ *Leonis.*
Præsepe	*Procyon.*
Regulus	*Ursa Majoris.*
ε *Hydræ*	*Regulus.*
Procyon	*Sirius.*
Castor	*Betelguese.*
Sirius	Ocean.
Regulus	*Naos.*
Procyon	*Sirius.*
30 Monocerotis	*Canopus.*
30 Monocerotis	*Naos.*
Denebola	*Ursa Majoris.*
Præsepe	*Procyon.*
Rigel	West.
Denebola	*Canopus.*
Rigel	Ocean.
Naos	*Canopus.*

(Too numerous to record).

Later—4 A.M.:—

From *Leo*	toward *Arcturus.*
Zenith	*Arcturus.*
Spica	*Mercury.*
Leo	*Mercury.*
Denebola	*Spica.*

These are a selection of the most prominent, all in this table having brilliant trails. The meteor appearing at $3^h 48^m$ near *Leo* shot to a point midway between *Orion's* head and the *Hyades* with terrific velocity and dissipated into cosmic debris with exceedingly brilliant greenish-blue light, estimated at twenty times the brightness of *Venus* at its maximum. The trail was probably 35′ in width and 15° in length. The nucleus disintegrated at π *Orionis.* The trail extended beyond *Betelguese.* It remained in the same place for ten minutes, expanding in width to 2°. It then bent at right angles, assumed the shape of the letter F, and slowly widened to a thick **F**. The top bar became detached and floated to *Aldebaran*, where its pearly light went out. The upright widened and lingered 14^m, when it waned and expired. A large meteor, or fire-ball, with splendid streamer emerged from the high east at 4^h 4^m and moved to the shoulder of *Ursa Majoris* with great speed. The nucleus dissolved into intensely brilliant matter and vanished, but the glowing band widened to 1°, bent into the form of the Greek letter Ω and remained in view 6^m. These two were all that had persistent light, none of the others remaining visible more than from half a minute down to the fraction of a second. On November 13, 1833, the *Leonids* put on display at Niagara Falls, and from the accounts written the vision must have been superb. But how is it possible to surpass the unearthly splendor here amid the mountains? The solitude at the midnight hour is supreme, and the silence awful in its intensity. Then fill the expanse of the sidereal vault with shot and shell hurrying in all directions, bursting into brilliant streams here and there, emerging like the swords of marshaled hosts from darkening space,—war without a trace of sound; and the effect is overpowering to brain, sensation, and imagination. Here where the silence at the third hour is so profound that an alert imagery of mind calls up sounds from the cañon's depths and from opposite granite walls,—voices from the unknown in the night,—and where the stillness is so deep that if the axis of the Earth in its turning made sound it would be heard in this place, unique on earth, a bombardment of *Leonid* meteors is impressive beyond the power of language to portray.

At $1^h 54^m$ a cloud suddenly condensed round about a summit and obscured *Leo* until $2^h 53^m$. A few straggling meteors were seen emerging from the edges, but they were not counted. Omitting these 59^m the rate of fall was 657 meteors in 281 minutes or 2.34 per minute. The fall from 4^h to $4^h 20^m$ was five per minute, and the highest number seen at once was five. The trend of nearly all was from *Leo* to west and southwest, a limited number going to the north. When *Leo* was well up some appeared to drop into Los Angeles' distant electric sea of lights, others into the ocean, and still others into the gaping mouths of the cañons. All this was due to perspective; none reached the Earth. The mirror of the heliostat was set on the rising point of the radiant and spectroscope adjusted in the hope of securing spectra. None was obtained. No meteor came from the exact radiant. After the cloud dissolved, at $2^h 53^m$, all was clear until dawn. And thus passed the memorable shower of *Leonids* of 1901.

LOWE OBSERVATORY, ECHO MOUNTAIN P. O., CAL., Nov. 18, 1901.

PLANETARY PHENOMENA FOR JANUARY AND FEBRUARY, 1902.

BY MALCOLM MCNEILL.

JANUARY.

January, 1902, is not a favorable month for observation of the planets, with the exception of *Mercury* and *Venus*. Several of the others are in the western sky for a short time after sunset, but they are too low down to be easily seen.

Mercury passes superior conjunction with the Sun on January 1st and becomes an evening star, but does not get far enough away to be conspicuous until after the middle of the month. At the end of the month it remains above the horizon about an hour and a half after sunset. It passes *Saturn* on January 6th, *Jupiter* on January 9th, and *Mars* on January 23d. The last named conjunction is rather close, *Mercury* being less than the Moon's diameter south of *Mars*.

Venus is pre-eminently the evening star, remaining above the horizon several hours after sunset, and being also at its greatest brightness early in the month. It can be seen in full daylight at any time during the month when it is above the horizon. It gradually draws nearer the Sun, although its eastward motion among the stars continues until January 22d.

Mars is still in the southwestern sky just after sunset, but has for some time ceased to be conspicuous. It remains above the horizon about an hour and a half after sunset on January 1st, but can not easily be seen on account of its low altitude and faintness.

Jupiter and *Saturn* are still not far apart, but the eastward motion of the Sun among the stars is so much greater than that of the planets that it overtakes and passes them,—*Saturn* on January 9th, and *Jupiter* on January 15th. The planets then become morning stars, but do not attain a sufficient distance from the Sun to make themselves visible as morning objects until after the close of the month.

Uranus passed conjunction with the Sun early in December, and is now to be found in the east just before sunrise, but too low and faint to be easily seen.

Neptune is above the horizon most of the night in the region between *Taurus* and *Gemini*, but can not be seen without a telescope.

February.

The conditions for observation of the planets are even worse in February than they were in January, except perhaps in the case of *Mercury*. That planet comes to greatest east elongation on the morning of February 3d, and up to the middle of the month does not set for more than an hour after the Sun. The present greatest elongation is only 18°; but the planet is a considerable distance north of the Sun, and this in a measure compensates for the smallness of the distance. At the following greatest east elongation toward the end of May the distance will be 23°.

Venus is still very conspicuous as an evening star, at the beginning of the month setting about two hours after sunset on February 1st; but it has begun its retrograde motion among the stars, and this in combination with the eastward motion of the Sun brings the planet into inferior conjunction with the Sun on February 14th. It then becomes a morning star and will remain so until November 28th.

Mars is still east of the Sun, and is near the southwest horizon just after sunset; but the Sun is rapidly drawing nearer to it in their common eastward motion, so that at the end of the month their distance apart is only 6°. Throughout the month the planet is too near the Sun and too faint to be seen without a telescope.

Jupiter and *Saturn* become morning stars in January, and by the close of the month will rise an hour and a half to two hours before sunrise. *Saturn* precedes *Jupiter* more than half an hour, but the greater brightness of *Jupiter* will make him more easily visible.

Uranus rises two hours or more earlier than the last two planets, and may be found in the region between *Scorpio* and *Sagittarius*.

Neptune is in about the same place as the one it held in January, between *Taurus* and *Gemini*.

EXPLANATION OF THE TABLES.—The phases of the Moon are given in Pacific Standard time. In the tables for Sun and planets, the second and third columns give the Right Ascension and Declination for Greenwich noon. The fifth column gives the local mean time for transit over the Greenwich meridian. To find the local mean time of transit for any other meridian, the time given in the table must be corrected by adding or subtracting the change per day, multiplied by the fraction whose numerator is the longitude from Greenwich in hours, and whose denominator is 24. This correction is seldom much more than 1^m. To find the standard time for the phenomenon, correct the local mean time by *adding* the difference between standard and local time, if the place is west of the standard meridian, and *subtracting*, if east. The same rules apply to the fourth and sixth columns, which give the local mean times of rising and setting for the meridian of Greenwich. They are roughly computed for lat. 40°, with the noon Declination and time of meridian transit, and are intended as only a rough guide. They may be in error by a minute or two for the given latitude, and for latitudes differing much from 40° they may be several minutes out.

JANUARY–FEBRUARY, 1902.

PHASES OF THE MOON, P. S. T.

Last Quarter . . .	Jan.	1,	8^h	8^m	A. M.
New Moon . . .	Jan.	9,	1	15	P. M.
First Quarter . . .	Jan.	16,	10	38	
Full Moon . . .	Jan.	23,	4	6	
Last Quarter . . .	Jan.	31,	5	9	A. M.
New Moon . . .	Feb.	8,	5	21	
First Quarter . . .	Feb.	15,	6	57	
Full Moon . . .	Feb.	22,	5	3	

THE SUN.

1902.	R. A.	Declination.	Rises.	Transits.	Sets.
Jan. 1,	18h 44m	—23° 4′	7h 26m A.M.	12h 3m P.M.	4h 40m P.M.
11,	19 28	—21 54	7 27	12 8	4 49
21,	20 11	—20 3	7 22	12 11	5 0
31,	20 53	—17 33	7 15	12 14	5 13
Feb. 10,	21 33	—14 33	7 4	12 14	5 24
20,	22 12	—11 09	6 52	12 14	5 36
Mar. 2,	22 50	— 7 26	6 37	12 12	5 47

MERCURY.

1902.	R. A.	Declination.	Rises.	Transits.	Sets.
Jan. 1,	18 43	—24 50	7 34 A.M.	12 2 P.M.	4 30 P.M.
11,	19 54	—23 0	7 57	12 34	5 11
21,	21 4	—18 36	8 9	1 4	5 59
31,	22 3	—12 14	8 6	1 24	6 42
Feb. 10,	22 26	— 7 20	7 32	1 7	6 42
20,	21 54	— 8 51	6 26	11 55 A.M.	5 24
Mar. 2,	21 29	—12 40	5 36	10 52	4 8

VENUS.

1902.	R. A.	Declination.	Rises.	Transits.	Sets.
Jan. 1,	21 45	—13 47	9 51 A.M.	3 4 P.M.	8 17 P.M.
11,	22 6	—10 11	9 20	2 45	8 10
21,	22 15	— 7 5	8 39	2 15	7 51
31,	22 9	— 5 5	7 47	1 30	7 13
Feb. 10,	21 50	— 4 45	6 47	12 31	6 15
20,	21 26	— 6 2	5 49	11 29 A.M.	5 9
Mar. 2,	21 12	— 7 56	5 2	10 35	4 8

MARS.

1902.	R. A.	Declination.	Rises.	Transits.	Sets.
Jan. 1,	20 8	—21 20	8 43 A.M.	1 27 P.M.	6 11 P.M.
11,	20 41	—19 29	8 29	1 20	6 11
21,	21 13	—17 17	8 13	1 13	6 13
31,	21 44	—14 46	7 56	1 5	6 15
Feb. 10,	22 14	—12 1	7 37	12 56	6 15
20,	22 44	— 9 4	7 17	12 46	6 15
Mar. 2,	23 13	— 6 0	6 56	12 36	6 16

JUPITER.

1902.	R. A.	Declination.	Rises.	Transits.	Sets.
Jan. 1,	19 33	—22 0	8 9 A.M.	12 52 P.M.	5 33 P.M.
Feb. 1,	20 4	—20 44	6 35	11 21 A.M.	4 7
Mar. 1,	20 30	—19 22	5 6	9 57	2 48

SATURN.

	1,	19 17	—22 6	7 55 A.M.	12 36 P.M.	5 17 P.[redacted]
	1,	19 32	—21 37	6 6	10 49 A.M.	3 32
:.	1,	19 45	—21 9	4 27	9 12	1 57

URANUS.

n.	1,	17 10	—23 0	5 52 A.M.	10 29 A.M.	3 6 P.M.
eb.	1,	17 17	—23 8	3 58	8 34	1 10
Mar.	1,	17 21	—23 12	2 12	6 48	11 24 A.M.

NEPTUNE.

Jan.	1,	5 59	+22 15	3 56 P.M.	11 16 P.M.	6 36 A.M.
Feb.	1,	5 56	+22 16	1 51	9 11	4 31
Mar.	1,	5 54	+22 17	noon	7 20	2 40

ECLIPSES OF *JUPITER'S* SATELLITES.

Jupiter is too near the Sun for observations of eclipse of satellites.

OBSERVATIONS OF THE VARIABLE STARS *W LYRÆ* AND *U*3 *CYGNI.*

BY ROSE O'HALLORAN.

According to the *Companion to the Observatory*, a minin of the long-period variable, *W Lyræ*, was due on May 8th a maximum on August 21st of this year. About sixty observa were obtained between April 21st and September 14th, bu following list includes only those showing distinct gradatio some seeming fluctuations. Clouds hindered observatio August 2d to 24th, but no doubt it was clear elsewhere the time of the predicted maximum. Three days after t the star had fallen to 9.4 magnitude, and unless the dec very rapid, it is probable that the maximum occurred lo the date of prediction, as it had risen to eighth magnit weeks previously. On April 21st and 26th, May 4th 8th it was invisible in a four-inch lens.

May 17. Equal to *t*, classed as of 12th mag.
" 23. Equal to *g* of 10th mag.

June	2.	Brighter than *g*, but less than *a* of 8.6 mag.
"	4.	Not so near the brightness of *a*, but equal to *p* of 9.4 mag.
"	10.	Equal to *e* of 8.8 mag.
"	21.	Brighter than *e*, but not fully equal to *a*.
"	23.	Equal to *a*.
"	29.	Brighter than *n* of 8.1 mag.
July	3.	Equal to *n*.
"	5.	Brighter than *n*.
"	7.	Equal to *n*.
"	8.	Brighter than *n*.
Aug.	1.	Equal to *n*.
"	24.	Less than *n*, equal to *p*.
Sept.	7.	Equal to *f* of 10th mag.
"	14.	Equal to *g*, which seems fainter than *f*, probably only one-tenth.

The comparison-stars used are those named in *Popular Astronomy*, No. 46.

U3 Cygni.

The following observations of this *Algol* variable, discovered by Madame Ceraski on photographs taken at the Moscow Observatory, include but one minimum, which occurred on June 14th. The normal brightness of the star seems to be about 9th magnitude, but on June 15th, 21st, 22d, July 24th, August 1st it rose to nearly 6th magnitude.

May	23.	10:00 P. M.	Midway between *a* and *f* of the comparison-stars named in *Pop. Ast.* No. 67, and is accordingly of 8.9 mag.
"	24.	9:30 P. M.	
"	27.	10:00 P. M.	Nearly equal to *a* of 8.6 mag., but less than *g* of 8.2 mag.
"	29.	9:40 P. M.	Equal to *f* of 9.2 mag.
"	30.	9:30 P. M.	
"	31.	9:30 P. M.	Brighter than *f*, dimmer than *a*.
June	1.	9:30 P. M.	
"	3.	9:30 P. M.	Not so near *a* in brightness, but still brighter than *f*. Night not very clear.
"	4.	8:53 P. M.	Still nearer to *f* than to *a*. Night clear.
"	5.	10:10 P. M.	
"	6.	9:00 P. M.	
"	7.	9:30 P. M.	Equal to *f*. Nights clear.
"	8.	9:00 P. M.	
"	9.	9:00 P. M.	
"	10.	8:45 P. M.	Brighter than *f*, not equal to *a*.
"	12.	9:00 P. M.	
"	14.	8:55 P. M.	It is barely discernible, probably of 12th mag.
"	15.	9:00 P. M.	It is equal to *a*, but less than *g*.
"	21.	9:15 P. M.	Nearly as bright as *a*.
"	22.	9.15 P. M.	

June	23.	9:00 P. M.	Equal to *d* of 9.6 mag.
"	24.	8:47 P. M.	Equal to *f*.
"	25.	8:50 P. M.	Equal to *f*.
"	26.	9:00 P. M.	Brighter than *f*.
"	27.	8:40 P. M.	Equal to *f*.
"	28.	9:00 P. M.	Equal to *f*.
"	29.	9:00 P. M.	Slightly brighter than *f*.
"	30.	9:00 P. M.	Slightly brighter than *f*.
July	2.	8:20 P. M.	Slightly brighter than *f*.
"	3.	8:40 P. M.	Slightly brighter than *f*.
"	4.	10:40 P. M.	Slightly brighter than *f*.
"	5.	8:50 P. M.	Slightly brighter than *f*.
"	7.	9:00 P. M.	Equal to *d*.
"	8.	8:45 P. M.	Brighter than *f*.
"	9.	8:30 P M.	Equal to *f*.
"	10.	8:30 P. M.	Brighter than *f*.
"	13.	9:00 P. M.	Brighter than *f*.
"	18.	8:50 P. M.	Equal to *f*.
"	24.	8:50 P. M.	Nearly equal to *a*.
Aug.	1.	8:30 P. M.	Nearly equal to *a*.

SAN FRANCISCO, September 21, 1901.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

OBSERVATIONS OF THE SPECTRUM OF *NOVA PERSEI*.†

At the time of the discovery of *Nova Persei*, the two single-prism spectrographs, with which all our low-dispersion photographs of the past ten years were secured, had just been shipped to Sumatra with the Crocker Eclipse Expedition. This shipment, including likewise several minor pieces of apparatus, left the spectroscopic resources of the Observatory temporarily inadequate for the efficient analysis of the star's light. The Mills spectrograph was too powerful for a qualitative study of the spectrum, and was limited in its action to parts of the blue and violet regions. Fortunately, we possess an abundant supply of large 60° prisms, both light and dense; and from these, in connection with the Mills spectrograph, new and efficient apparatus was designed and constructed as required.

In all the spectrographs employed, and described below, the collimator section of the Mills spectrograph was used; and the changes made relate entirely to the prism-boxes, cameras, and braces for supporting the cameras. It will be a convenience in the discussion of the observations to have some ready method of referring to the different combinations of apparatus.

The Mills spectrograph, as ordinarily employed, will retain its usual designation.

The other instruments, referred to as spectrographs I, II, III and IV, will now be described.

I. A brass prism-box, designed some years ago by Mr. CAMPBELL, for converting the Mills spectrograph into a one-prism instrument, was made ready for use by the evening of February 25th. It contained a single 60° light flint prism, and carried the regular Mills camera of 406^{mm} focal length. The instrument was found to give excellent definition from above λ 3700 to λ 5700.

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† Condensed from Lick Observatory *Bulletin*, No. 8.

By tilting the plate slightly, the definition was equally good from λ 4000 to λ 6000.

II. A large 60° dense flint prism, and a visually corrected triple lens of aperture 5^{cm} and focal length 53^{cm}, were mounted in wood, and attached to the collimator section of the Mills spectrograph. Most of the visual observations, and some photographs in the yellow and orange regions, were secured with this instrument. It replaced spectrograph I late in the evening of February 25th, and visual observations were obtained. The fine dark *D* sodium lines in the broad bright *D* band were seen at once, and with ease. The dark lines were compared directly with the bright *D* lines from an alcohol flame; and the star's lines were estimated by the two observers, respectively, to be displaced to the red about an eighth and a tenth of the distance between D_1 and D_2. These estimates—corresponding to radial velocities of 38 and 30 kilometers per second—were in close agreement with the photographic results [see page 231] secured a few nights later.

III. It was considered very desirable to obtain high-dispersion photographs of the *D* region. As the Mills spectrograph is limited to portions of the blue and violet, it was necessary to construct another prism-box and some auxiliary apparatus to secure the desired result. A prism-box to hold three very dense 60° prisms was constructed of wood by the Observatory carpenter from designs by Mr. WRIGHT. The whole matter of designing, constructing, adjusting, and testing the apparatus required a day and a half. The instrument gave excellent results; no effects of flexure or shrinkage of the wood during the long exposures were visible. With the 406^{mm} camera, the separation of the *D* lines is 0.15^{mm}.

IV. Another box, similar in design to the one described in the preceding paragraph, was constructed for the purpose of photographing the *H* and *K* regions under high dispersion. It was lighter in some of its parts, and gave evidence of flexure. Results of value were secured with it, however. The three Mills prisms were used in this box, as the denser ones were entirely too yellow for work in the violet.

The comparison-lines used include those of iron, magnesium, sodium, hydrogen, and helium. Wave-length determinations have in all cases been based on the Hartmann-Cornu formula.

The spectrum was recorded from $H\delta$ to $H\beta$ on February

24th, with the Mills spectrograph. The $H\delta$, $H\gamma$, and $H\beta$ bands of hydrogen were bright and extremely broad, and were accompanied on their violet sides by very broad absorption-bands. Otherwise, the spectrum appeared to be strictly continuous. The absorption in the dark bands was only partial, so that the contrasts between bright and dark bands were very slight. The $H\beta$ bands were easily visible, but the $H\gamma$ and $H\delta$ bands were rather difficult, as a result of the too strong dispersion afforded by this instrument. The general character of the spectrum would have been shown much better by one-prism spectrograms.

On February 25th, photographs were secured with spectrograph I, and the star was observed visually with spectrograph II. Numerous bright and dark lines were easily observed; and while allowance must be made for the lower dispersion used, it is safe to say that in the region of the spectrum photographed on the preceding night, the bright bands and the contrasts between bright and dark bands were relatively much stronger. The bands appeared to be identical with those in the early spectrum of *Nova Aurigæ* (February, 1892), but in the earlier star the bands were much narrower and the contrasts were vastly stronger.

$H\alpha$ was very bright, and situated with reference to the artificial $H\alpha$ line in the same manner as the other hydrogen bands with reference to their normal positions. It was accompanied on the more refrangible side by its corresponding dark band. A very bright and broad band in the orange, presumably due to sodium radiations, was crossed by two apparently monochromatic dark lines. These were identified as D_1 and D_2. To the violet of this band was the usual absorption. It covered the normal position of D_3, but there is no reason to suspect that it related to the element helium. Besides the five well-known *Nova* bright bands in the region of λ 4860 to λ 5270 no further details could be observed visually, on account of the strong continuous spectrum which masked the fainter bands.

The spectrograms obtained on February 25th extended from λ 3830 to λ5700. One of these, enlarged 7-fold, is reproduced in the accompanying sheet of illustrations (Fig. 1). Perhaps the most striking features of the plates are the broad bright and dark H and K bands, the bright components being crossed by fine dark H and K lines (Fig. 5). The band at H is evidently the result of the superposition of the $H\epsilon$ (hydrogen) and H

(calcium) bands. The fine *H* line is apparently not so black as the *K* line, though allowance must be made for the different densities of the negative at the two places.

The violet edges of the bright bands are the more sharply defined, except for the *K* band, in which the reverse is the case. The hydrogen bands are very broad and diffuse, and it is difficult to locate the positions of maximum with accuracy. There seems, however, to be a decided shift of the maxima to the violet of the normal positions of the hydrogen lines, by an amount greater than the probable error of measurement.

The next photographs with the same apparatus were secured on March 13th, by which time the spectrum had greatly changed. These changes appear to be more pronounced in the photographs taken on March 18th, and these two sets will be considered together. The spectrograms show the *K* band to have disappeared. Most probably the *H* band shared a similar fate, though it is impossible to prove this, on account of the superposition of the $H\epsilon$ band, referred to above. The fine *H* and *K* lines remain, but the absorption in the former appears to be less complete than before. The maxima of the bright hydrogen bands are shifted several tenth-meters toward the red from the normal positions of the hydrogen lines.

It is, however, in the dark bands accompanying the bright ones that the changes are most marked. The former broad, diffuse absorption-bands are replaced by multiple fine lines. Of these lines, the one of greatest wave-length is many times the most intense, and practically terminates the bright band with which it is associated. Two other lines were observed with certainty in many of the groups, and were suspected in all the groups, except $H\zeta$, where the spectrum was too faint for reliable observation.

The displacements of the principal dark lines from the normal positions of the hydrogen lines vary considerably from one end of the spectrum to the other, but seem to be very approximately proportional to the wave-lengths. In the following tables the means of the displacements for the two dates are given in the second column, while those computed on the assumption of direct proportionality to the wave-lengths are given in the third. The assumed proportion is represented by the equation $\Delta\lambda = 0.00505\lambda$.

Line.	Δλ Observed.	Computed.	O — C	Wt.
H_ζ	19.28 t. m.	19.64 t. m.	— 0.36 t. m.	1
H_ϵ	20.04	19.98	+ 0.06	1
H_δ	20.51	20.79	— 0.28	1
H_γ	22.18	22.91	+ 0.27	1
H_β	25.7	24.5	+ 1.2	½

The wave-lengths in the neighborhood of $H\beta$ cannot be determined with great accuracy from these plates, on account of both the relatively low dispersion in that region of the spectrum and the unsatisfactory nature of the comparison-lines available for measurement. In the determination of the constant of proportionality the $H\beta$ result was therefore given weight one-half. Considering the unsymmetrical distribution of light on the two sides of the absorption-lines, it is safe to say the residuals (O — C) are commensurate with the errors of measurement. The proportionality of the displacements of the dark hydrogen lines to their wave-lengths therefore appears to be a fundamental characteristic of the star's spectrum at this stage of its development.

We shall refer to the displacements of some of the other dark lines, the origins of which are open to little doubt. While the dark *H* and *K* bands were in evidence, they were displaced toward the more refrangible end of the spectrum by about 16.5 t. m. On account of the breadth of the bands, the measured displacement is liable to an error of perhaps two tenth-meters. The displacement computed by means of the proportionality assumed above is 20 t. m. The displacement of the dark *D* band (due to sodium), which will be referred to below, is 27 t. m. The error of measurement of the position of this band is influenced by its breadth, and to some extent by the sensitiveness-curve of the "isochromatic" plate used, which is very steep in this region of the spectrum. The tendency would be to make the measured displacement smaller. The computed displacement is 30 t. m.

The computed displacements given above depend, as has been said, on measurements of the fine hydrogen lines which developed after the calcium bands had disappeared, and probably after the spectrograms of the *D* band had been secured. It might therefore seem more reasonable to compare the displacements of the calcium and sodium bands with those of the diffuse bands of hydrogen which existed simultaneously with them, and resembled them somewhat in their general characteristics. The displacements of the hydrogen bands are —

Line.	$\Delta\lambda$
$H\delta$	— 19 t. m.
$H\gamma$	— 19
$H\beta$	— 24

From these we obtain the equation $\Delta\lambda = 0.0046\lambda$. The observed displacements, and those computed on this basis, are —

Line.	$\Delta\lambda$	
	Observed.	Computed.
K	— 17 t. m.	— 18 t. m.
H	— 16	— 18
D	— 27	— 27

The agreement is closer than that resulting from the first assumption. There is, then, no evidence that the position of the bands is affected by other considerations than that of wave-length.

The other features of the spectrum are shown in the reproduction of one of the plates of March 18th (Fig. 2), directly enlarged from the original negative.

The spectrograms for February 25th and March 18th are not strictly comparable on the red side of $H\beta$, for the reason that the plates used on the two dates were of different character. The earlier spectrogram was made on a Cramer isochromatic plate, and the later one on an ordinary Cramer Crown, a plate not sensitized to the lower rays. In all of the plates secured on March 13th and 18th, the region λ 4600 – λ 4700 was overexposed, and the details thereby destroyed.

During the early part of April the appearance of the spectrum was as is indicated in Figure 3. The triple absorption-lines referred to above had so decreased in intensity as to make their recognition very uncertain. A broad and diffuse absorption had developed in the neighborhood of the normal position of the three principal hydrogen lines. $H\zeta$ is just on the limit of visibility on the photographs, and no details can be observed with certainty in that region. The spectrogram of April 5th was made on a Cramer isochromatic plate, as was also that of February 25th, so that the two should be comparable.

It was not possible to observe the star every night over a long period of time, for the purpose of detecting rapid variations in the spectrum; such ones, for instance, as might accompany the more or less periodic changes in the star's brightness. In general, it was noticed during the spring months that the bright bands were relatively more intense at minima than at maxima of the star's brightness; that is, that the variations affected the continuous spectrum more than the bright lines. We recognize that physiological effects may play an important part in such estimates, however. Definite changes certainly occurred between April 1st and 5th. The bands λ 4629 and λ 4675, appearing on the spectrogram of April 5th, are not on that of April 1st; and the bands of April 1st at λ 4583 and $\lambda\lambda$ 4632–4661 are not recorded on that of April 5th. The band at λ 4675 was too faint to record itself on the earlier photograph. The changes described could be caused by variations in the relative intensities of one or two of the bands concerned.

The absence in Sumatra of the principal parts of the large visual spectroscope prevented visual measurements of the spectrum. There was little need for these, however, as the isochromatic plates afforded vastly more valuable observations down to and including the *D* region; and the $H\alpha$ band was photographed with erythro plates, as well as observed visually. In February no bright bands were visible except those which have been mentioned above or described in the tables. As the star grew fainter, additional bands were observed. At the times of the last visual observations, on April 14th and 21st, essentially all the bands observed in the early sprectrum of *Nova Aurigæ* were present. Those at λ 5760, λ 5840, λ 6160, and λ 6300 were easily seen. The last photographic observation was secured on April 14th.

The spectrum was observed visually on two evenings, with instrument I, for the purpose of determining whether the light of the star was plane-polarzied to any extent. The slit was opened wide, and a Nicol prism was held in front of the eyepiece. As the prism was rotated, no narrowing of the lines, or other phenomena, were observed, except a slight darkening of the spectrum as a whole, due to the polarizing effect of the spectroscope. The results furnish no evidence of a Zeeman effect in the star, but in some respects the evidence is merely of a negative character.

The velocities in the line of sight determined from measurements of the fine dark *H* and *K* calcium lines on all the plates secured up to and including March 18th, with spectrograph I, are contained in the following table:—

Date	Plate No.	Velocities. *H*	Velocities. *K*
Feb. 25	2023C	-4^{km}	$+6^{km}$
	2025C	$+2$	$+5$
	2026D	——	$+13$
Mar. 13	2049C	-6	$+13$
	2050D	$+22$	-4
Mar. 18	2056C	——	$+14$
	2057D	$+7$	$+7$
	Means	$+4.2^{km}$	$+7.7^{km}$

These values are corrected for the orbital motion of the earth, but not for diurnal motion and the curvature of the spectrum lines. These corrections are -0.2^{km}, and -0.3^{km}, respectively. Applying them to the mean of the individual determinations, we have $+5.7^{km}$ per second as the observed radial velocity of the star. This value was used in correcting all the wave-lengths determined with spectrograph I.

Recalling that the above individual results depend each upon measures of a single line, on plates secured with an instrument containing only one light flint prism, whereas the current results with the Mills spectrograph depend upon measures of many lines dispersed by three dense flint prisms, the linear values of the discrepancies are seen to be small.

A spectrogram of the *H* and *K* region secured on March 5th with spectrograph IV yielded the following velocities, from the fine dark lines:—

$$H, \ +6.5^{km}$$
$$K, \ +8.1$$
$$\text{Mean}, \ +7.3^{km}$$

A discrepancy of 2.5^{km} at $H\gamma$ corresponds in linear value to 1.8^{km} at *H*.

These dark lines were very narrow. The measured widths on the above plate were 0.22 t. m. and 0.28 t. m. respectively, including the effects of flexure of the instrument in broadening the lines.

Spectrograms of the *D* region were secured on February 26th, 27th, 28th, and March 3d, 14th, and 17th, with either low or high dispersion. While some of the low-dispersion plates are quite satisfactory, those of high dispersion are so much more so that results from the high dispersion alone will be considered. One of the atter was obtained on February 28th, and is reproduced in Figure 4. The position of maximum is apparently to the violet of the *D* absorption-lines; but the slope of the sensitiveness-curve of the plate, referred to above, would have a very strong tendency to shift the apparent maximum to the violet, so that it is impossible to locate the actual position of greatest intensity.

The radial velocities of the *Nova* determined from the *D* lines on these plates are as follows:—

Date.	Plate No.	Velocity. D_1	Velocity. D_2	Mean.	Corr. for Curv.	Red to Sun.	Velocity.
Feb. 28	2034C	+38.7	+33.8	+36.1	−2.7	−27.3	+6.1^{km}
Mar. 3	3040D	+33.8	+25.8	+29.8	−2.3	−27.0	+0.5
						Mean velocity with reference to Sun,	+3.3^{km}

In comparing these results for the *D* region with those secured from ordinary line-of-sight work in the violet region, it is necessary to bear in mind the matter of relative prismatic dispersion for the two regions. In the Mills spectrograph work at $H\gamma$ we should be satisfied if the discrepancy between the values secured from two plates, on each of which only two lines had been measured, were less, say, than 2½ kilometers per second. The linear value of the discrepancy between the above results, 6.1 — 0.5 = 5.6^{km}, would correspond to 2.4^{km} at $H\gamma$, with the Mills spectrograph.

As a check on these results, the *D* lines were measured on a spectrogram of the planet *Mars*, taken under similar conditions. The difference between the observed and computed velocities, —2.2^{km}, corresponds to — 1.0^{km} at $H\gamma$, and is satisfactory.

The *D* absorption-lines are very narrow. A comparison of their widths with those of the corresponding lines in the solar spectrum is not without interest. A measurement of one of the plates places their width at 0.8 t. m. The width of the solar lines according to ROWLAND's tables is 0.17 t. m. It was considered better, however, to compare the two spectra under the same instrumental conditions. The widths of the *D* lines on a spectrogram of *Mars* and on one of the Sun were therefore measured, with the following results:—

Line.	*Mars.*	Width in Sun.	*Nova.*
D_1	1.0 t. m.	0.9 t. m.	0.8 t. m.
D_2	1.2	1.1	0.8

The solar and planetary lines are probably somewhat broadened by the presence of unresolved companions, but it is evident that the breadths in the two cases are of the same order. The last spectrogram of the *D* region, secured in the spring, was a low-dispersion one taken on March 17th. It showed the general features to have remained practically unchanged.

For convenience, the determinations of radial velocity referred to above are here collected:—

Spectrograph I, *H* and *K*, $+ 5.7^{km}$
Spectrograph III, D_1 and D_2, $+ 3.3$
Spectrograph IV, *H* and *K*, $+ 7.3$

In addition to the spectrograms on which these results depend, a number of others recorded the absorption-lines of sodium and calcium. Within the limits of error of measurement, all give accordant results. There is no evidence that the velocity is variable; and this view is strongly confirmed by the results of the summer series of observations, to be described below.

Spectroscopic observations of *Nova Persei* were discontinued from April 21st to July 9th, while the Sun was passing through this region of the sky. Our regret that the southern position of the Lick Observatory prevented observations in this period is coupled with the hope that the observatories of northern Europe were able to obtain a practically continuous series.

Our summer series of observations has been secured mainly with spectrograph I. The first observation of the series was made on July 9th. As announced by Professor PICKERING, the spectrum at this time was that of a nebula. The usual nebular lines are represented by broad bright bands. The several spectrograms obtained at well-distributed intervals since July 9th do not show that any pronounced changes have occurred in this time. Spectrograms covering the region $\lambda 3800 - \lambda 5900$ are reproduced in Figures 6 and 8.

The $H\alpha$ band is very bright, but no other details additional to those on the photographs have been shown by the visual observations.

A striking feature of the spectrum is the distribution of the light in most of the bands. In general, there is a maximum, considerably displaced to the violet of the normal position of the nebular line. This maximum is accompanied on its less refrangible side by a pronounced minimum. In most cases another

Fig. 1.

FIGURE 1.—*Nova Persei*, enlarged 7-fold. 1901 February 25.

Fig. 2.

FIGURE 2.—*Nova Persei*, enlarged 7-fold. 1901 March 18.

Fig. 3.